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The Windrow Method of Combine Harvesting - - - - - - - - - *A. J. Schwantes*

Harvesting Navy Beans With the Combine - - - - - - - - - - - - *E. C. Sauve*

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Results of Studies of Drying Combined Grain - - - - - - - - - - - - *W. M. Hurst*

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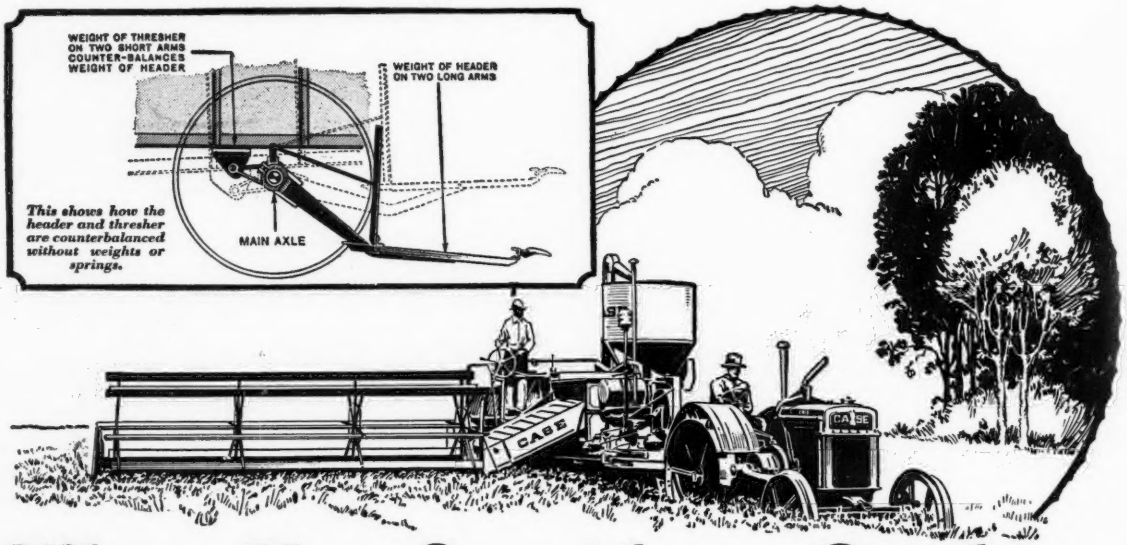

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AGRICULTURAL ENGINEERING

Vol. 10 FEBRUARY, 1929 No. 2

Some New Developments in Combine Harvesting in Idaho[1]

By Hobart Beresford[2] and E. N. Humphrey[3]

DURING the harvest season of 1928 a continuation of the study of the operation of combine harvesters has been in progress. Working under the plan established in 1927 a group of tractor and horse-drawn outfits have furnished daily operation reports. In addition to the general data, which checks very closely the information obtained in 1927, the following new developments in combine harvesting in Idaho have been observed:

1. Combining peas in the Palouse region
2. Horse and tractor combination hitch for combine operation
3. Carrying the front end of the combine direct on the tractor
4. Combine attachment for handling large weeds
5. Bulk handling of wheat in the Palouse region
6. Laying out fields for bulk combining.

Combining Peas in the Palouse Region. In addition to the regular windrow pick-up, the study of combine operation in Idaho has revealed two methods for harvesting peas which have been developed independent of the machine manufacturers. For harvesting from the standing vines three types of attachment have been used on the machines studied during the past season. One hillside type (Holt) combine was equipped for pea harvesting by dropping the sickle to the ground and extending it forward about 3½ feet. A flexible rack made of flat steel strips was carried between the sickle and the platform. The slats were about 1½ inches in width and spaced 6 to 8 inches on centers. This arrangement allowed the stones and clods to filter through but prevented the loss of vines. The sickle drive was accomplished by an extension of the regular driving shaft equipped with a universal joint. The cutter bar was equipped with a standard type of guard supplied with mowers used for pea harvesting. This machine harvested 100 acres in 45⅓ hours operating time, the yield of peas being 890 sacks weighing approximately 140 pounds per sack. Field observation of the operation of this attachment indicated that is had reached a satisfactory stage of development.

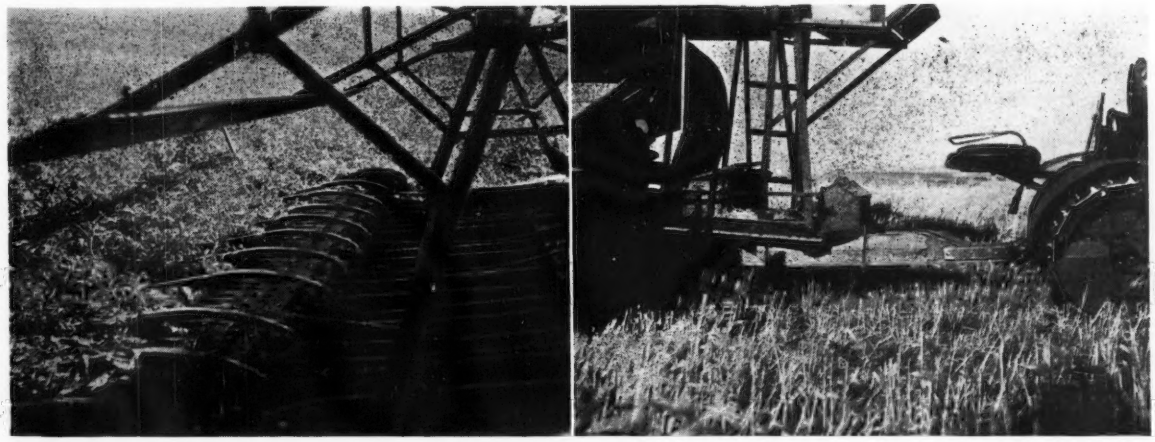
Another type of pea harvesting attachment was applied to a hillside type (Case) 14-foot combine equipped with special guards of the farmer's own design. The platform was tilted at a rather sharp angle with the intention of picking up the vines and carrying them direct to the platform. Careful operation and regulation of the header platform produced satisfactory results. A third type of pick-up was applied to a hillside type 12-foot (Holt) machine on which the cutter bar was equipped with flexible guards of the farmer's own design. Field operations indicated that when the machine was working in fairly thin vines and the header platform was tilted to within 4 to 6 inches of the ground, its operation was satisfactory.

The development of the pea harvesting attachments has been left largely to the individual combine owner due, in part, to the limited area in which successful combining of peas is possible. Of the outfits described, the first one has proven to be the best adapted to the various conditions. The owner who developed this type of attachment plans to equip a second machine and plant 600 acres of peas for the coming season.

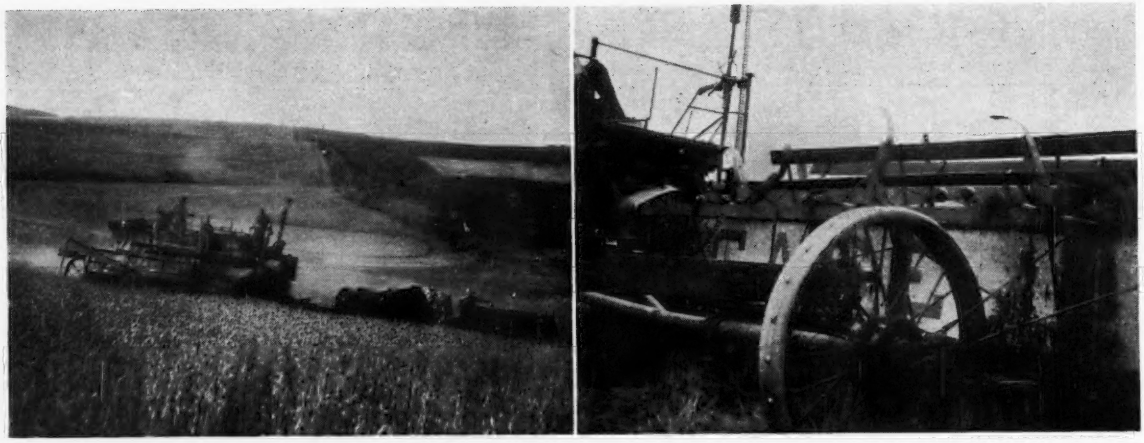
[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Head of the department of agricultural engineering, University of Idaho. Assoc. Mem. A.S.A.E.

[3]University of Idaho Agricultural Experiment Station.



(Left) The most successful pea harvesting attachment operated in the Palouse region during the 1928 harvesting season. (Right) The front end of a combine carried directly on the tractor



(Left) A tractor-horse combination at work. This view also shows the hills characteristic of the Palouse region. (Right) View showing beaters and drive mechanism attached to a combine for handling large weeds

The second method of harvesting peas is from the vines in the shock. For this method one operator has used a Rumely 15-30 tractor and a regulation hillside type 12-foot (Case) combine with the reel removed and the guards covered with a wide board. The peas were mowed, raked and bunched with a sulky rake after which the combine was hauled along the field and the peas pitched on the platform by hand. Four to six men were required for feeding the machine and three men were required to handle the combine and tractor. The cost for threshing peas with a stationary machine under similar conditions was $1.00 per sack while the charges made by the outfit described above were 50 cents a sack. The additional cost of gathering the sacks in the field and for the feeding value of pea straw should be added to the latter figure.

The Horse and Tractor Combination Hitch for Combine Operation. The change from muscle to mechanical power for combine operation in the Palouse region has undoubtedly been delayed because of the topography, physical characteristics of the soil, and established farming practice. Many farmers favor the use of horses for seeding, claiming that the tractor produces undesirable results due to packing the light soil. For this reason many tractor owners have continued to keep horses for the seeding operation.

During the season of 1927 adverse weather conditions delayed the harvesting and produced difficulties in field operation which caused one of the operators to combine his teams and tractor for handling the combine in the wet fields. The combine operated under these conditions was one of the earlier types and weighed approximately 13,000 pounds. The hitch developed for hitching the horses and tractor to the combine has worked out very satisfactorily. The horses were tied in, six abreast back of the tractor. The team depended upon the tractor operator for its direction. This arrangement has produced surprising results because the horses soon learn to coordinate their movements with the tractor. Field observations revealed that as soon as the motor of the tractor started to speed up preparatory to letting in the clutch, the horses would move forward and be ready to take up their share of the load. On the level and downhill grades the horses would slack up allowing the hitch mechanism to throw the entire load of the machine on the tractor. This was partially due to the increase in the rate of travel of the outfit and the fact that the horses were moving faster than they would have ordinarily traveled under full load. The ratio of load proportioned to the team was approximately 29 per cent and should depend upon the size of the tractor and number of horses used in the combinations.

Carrying the Front End of the Combine Direct on the Tractor. On one of the hillside type (Holt) combines the operator removed the front wheel and, by means of a beam clamped to the wheel carriage, extended the point of application ahead of the combine, attaching it directly to the tractor. The additional weight of the combine thus applied increased the ease of handling and improved the tractive application of the outfit. Field observation revealed that the regular Thirty "Caterpillar" tractor thus equipped was able to handle the combine on an equal with the special type of Thirty "Caterpillar" tractor provided for this region, known as the "Palouse Special."

Combine Attachment for Handling Large Weeds. Nearly every combine operator has experienced difficulty with a weed patch in one of his fields. This difficulty usually results in the piling up of the weeds on the platform apron just before they enter the elevator. One combine owner developed an attachment for handling large weeds and heavy grain. Three beaters were mounted above the platform driven by a standard worm gear reel drive. A small flat beater was mounted above the mouth of the elevator apron and driven by a chain and sprocket from the nearest beater shaft. A square shaft extended through the worm gears of the beaters and was driven from a chain and sprocket attached to the apron drive. This outfit was able to handle extremely weedy wheat without apparent difficulty.

Bulk Handling of Wheat in the Palouse Region. The bulk handling of wheat in the Palouse region has been considered impractical because of the extremely hilly fields over which the combine must operate. A method for bulk handling under the Palouse region conditions has been developed and practiced during the last season. A model Thirty-two hillside type (Holt) combine, equipped with grain tank and elevator, was used by one operator for harvesting 300 acres of wheat this fall. The grain was hauled from the field by two teams and wagons and elevated to a portable field bin conveniently located for the motor truck. From this bin the wheat was hauled by motor truck 5.3 miles to the central elevator. The truck averaged 14 to 16 trips a day with a maximum of 17 trips totaling 180 miles, hauling an average of 4400 pounds of wheat per load. Handling the bulk grain at the elevator by means of a grating over the elevator pit avoided overloading the elevator equipment when the truck load of wheat was dumped.

The advantages of bulk handling in this region are obvious, providing the proper equipment and practical methods are employed. A reliable means of transferring the wheat from the wagons to the field bin is absolutely essential. Transportation from the field bin to the central

elevator must be reliable. The cost of the bulk handling when compared to the sacking method is in favor of the bulk handling. The disadvantages of sacking are the added expense for sacks and the fact that many sacks may never be found, which may mean loss of livestock by foundering.

Laying Out Fields for Bulk Combining. In the bulk handling of grain with the combine it is important that the truck hauling the grain from the machine travel the least possible mileage to and from the elevator if the most economical results are to be obtained. On a 1700-acre wheat field an example of a desirable practice in laying out fields for combining was observed this fall. From a point nearest the central elevator the combine owner entered and proceeded as near as possible to the center of the field. From this point the machine was operated in a spiral course. After the edges of the field were reached the corners were cut out separately. The motor truck was able to use the entrance path of the combine for making the haul between the machine and the field entrance thus keeping the distance travelled at a minimum regardless of the position of the combine in the field.

Grain Loss Tests of Combine Harvesters in Missouri[1]

By M. M. Jones[2]

DURING the past year the department of agricultural engineering of the University of Missouri has made studies and observations on the use of combine harvesters in the state. In 1927 there were about fifteen combines in Missouri. In 1928 this number increased to between sixty and sixty-five. The majority of these additional machines were sold just at the beginning of wheat harvest in 1928 or after harvest had actually begun. The prospects for wheat throughout the state were poor during the spring, and many orders for machines were cancelled.

These sixty or sixty-five machines are located mostly in the river bottoms of the Missouri, the Mississippi, and some of their tributaries, with a few in the southwest level prairie section and a few in the northeast section of the state. The machines are used principally for harvesting wheat. Oats, barley, soybeans, and sweet clover were other crops harvested in Missouri. More combines would be purchased primarily for soybean harvest were is not for the fact that many of the beans grown for seed in Missouri are grown in small fields, with only a few acres on each farm. In 1928 fewer acres of beans were grown, probably due to the open weather in the spring which enabled farmers to put much of the land into corn.

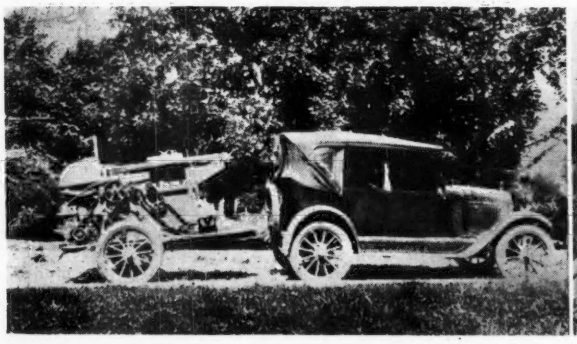
For making threshing efficiency tests of combines, a small threshing machine (an Owens pea and bean huller) was remodeled and mounted on a light two-wheel trailer to be pulled behind an automobile. A 4-hp. Cushman engine was mounted on the same trailer. This outfit was taken to various parts of the state and tests were made on the combines as we found them working the fields. The method of making the tests was briefly as follows: A canvas sheet about 14 by 16 feet with a light-weight folding pipe bar on each side to keep it taut, was carried by two men along behind the combine to catch all the straw and chaff discharged from the machine over a certain distance. Over exactly the same distance, the threshed grain delivered by the combine, was caught in a sack. The length of the test varied from about 75 to 150 feet; the distance depending principally upon how far two men could carry the accumulated straw. The length of the test was always measured immediately, as was also the width of the swath at from four to six places.

The sample of straw was threshed through the small test thresher, after being forked and agitated thoroughly to sift out the threshed grain from the straw. The grain recovered from this forked straw was designated as grain left in the heads by the combine. The chaff from the sample of straw was threshed through the test thresher separately, and the grain thus recovered was designated as grain threshed by the combine but not separated from the straw. In operating the small test machine a very small amount of air was used in cleaning the grain, in order to make sure that none was blown over. The recovered grain generally was dirty and chaffy, but was easily cleaned by hand on dockage sieves. From the amount of grain recovered and the amount of grain delivered by the combine over the test area the percentage lost by the machine was calculated.

The cutter bar losses which in our tests were generally more than the threshing losses, were measured by carefully picking up all the grain on a certain number of small areas selected at random behind the cutter bar. Usually the

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Associate professor of agricultural engineering, University of Missouri. Mem. A.S.A.E.



(Left) For making the Missouri threshing efficiency tests an Owens pea and bean huller was remodeled and mounted on a light two-wheel trailer and pulled behind an automobile (Right) Showing method of making the tests in the field

grain was picked up from six areas, sometimes more and sometimes fewer, each area being one square yard. A light frame enclosing exactly one square yard was cast ahead eight or ten feet. After picking up all the grain on the ground enclosed, the frame was again cast, six casts usually being made for each test. The recovered grain was threshed and cleaned by hand.

RESULTS OF TESTS

In the tests of combines operating in wheat, three were unusually high in machine losses (13.36, 15.25 and 20.50 per cent). All three of these tests were made under extremely bad and very unusual conditions. In fact the wheat would in all probability not have been harvested at all had a combine not been available to do the work. In one case the wheat had been under 10 feet of water just as it was ripening. It therefore did not mature properly. The grain was coated with mud when the water went down and at threshing time it tested only 50 pounds per bushel. In the other two cases, the weeds were much thicker and higher than the wheat and most farmers would not have attempted to harvest the grain by any method. Omitting these three admittedly unusual tests, the machine losses averaged (for 24 machines) 1.93 per cent. This is considered very satisfactory in view of the unfavorable operating conditions.

The cutter bar losses on these twenty-four tests averaged 0.95 bushel per acre. The cutter bar loss in bushels per acre was higher in most cases than the machine or threshing loss. This is a point apparently not recognized by most of the operators of the combines. Of course, by cutting lower the cutter bar losses are generally reduced but the threshing losses may be raised somewhat on account of the extra straw or weeds the machine would have to handle. The losses, both threshing losses and cutter bar losses, are higher than losses reported by some other stations. This is to be accounted for largely by the unfavorable weather and field conditions under which most of the combine work in Missouri was done in 1928.

There was much winter-killed wheat. Many fields had very thin stands and were, therefore, weedy. Also more rain fell in the month of June than in any other previous June in the history of the weather bureau. Also in July there was so much wet weather that harvesting was seriously interrupted and delayed. Consequently there was considerable lodging of the grain with increased cutter bar losses. Most of the grain was cut low in an attempt to get the leaning heads. This required the combines to handle considerable extra straw and also green weeds in the weedy fields. The weeds caused the most trouble by clogging the screens and riddles and by preventing threshed grain from shaking through the straw on the straw racks. The operators of the machines being for the most part inexperienced, doubtless also accounts for some of the higher threshing losses.

Loss Tests of Binders and Threshers. Tests were made on thirteen threshing machines working in wheat. The machine losses were somewhat lower than the corresponding losses in combines. The average machine loss was 1.28 per cent against 1.93 per cent for combines.

The cutter bar losses in fields where threshers were tested averaged 0.53 bushel per acre against 0.95 bushel per acre for combines. Shock losses averaged 0.25 bushel per acre. It must be pointed out that both the cutter bar loss and the shock loss are really higher than these figures would indicate, because at threshing time it was very difficult or impossible to pick up all the grain left under the cutter bar. Much grain had been covered by mud during rains, and some had sprouted. Therefore, the grain recovered in the ground-loss counts did not represent the total loss. Also the shock-row loss between shocks, which was counted as a part of the shock loss, was not the total loss for the same reason. In several cases there was sprouted grain in the shock. This loss was not measured in our tests and was not counted in the total losses of the binder-thresher method.

Windrowers and Pick-Up Attachments. There were only a few windrowers used in Missouri in 1928, probably only four. Loss tests were made on two. The cutter bar loss in one case was 0.59 bushel per acre; in the other it was 0.34 bushel per acre, or much lower than the average cutter bar losses. The windrow loss in the first case was 0.28 bushel per acre and in the second 0.32 bushel per acre. The harvesting rate was materially increased in both cases by windrowing, even counting the time for windrowing. It cannot be stated that this would be the case always. These two farmers were quite enthusiastic about the windrowing method. Doubtless many other combine owners would have profited by the use of windrowers and pick-up attachments.

The use of one windrower on soybeans was apparently unsuccessful, due to two factors, inability to cut low enough and continued wet weather. The beans were cut 5 to 9 inches high and the cutter bar loss was about 3.4 bushels per acre. Due to wet weather, there was considerable delay in threshing and consequent loss from shattering and sprouting.

Combining Soybeans. A few tests of combines working in soybeans have been made in Missouri. The threshing losses have been very small. The cutter bar and shattering losses have varied from as low as 0.12 bushel per acre to as high as 5.4 bushels per acre. The cutter bar losses depend primarily upon the variety of beans, the height of cutting, and upon the stage of maturity when cut.

Moisture Content. Whenever a combine test was made a sample of grain was also collected for moisture determination. In the tests on wheat, the moisture ranged from 11.0 to 19.1 per cent, averaging 14.35 per cent for twenty-six samples. Most farmers had very little difficulty in handling the combined grain, most of the grain being sold direct from the combine. In at least one case, the grain was put into a bin as it was threshed and then hauled to the elevator the next day. This, of course, involved extra labor in handling, but it indicates that enough moisture was removed in one day to make it acceptable to the grain buyer. By following this practice it was possible to work a little earlier in the morning.

In one case of threshing from the windrow, the moisture was 11.0 per cent. The grain had been in the windrow two days. In the other case, the moisture was 14.0 per cent, even though the straw was very tough from a recent shower. The grain had been in the windrow ten days and had had three heavy rains on it. Sweet clover was growing up into the windrow, making the safety clutch on the pick-up drive slip frequently.

The range in moisture content of the thirteen samples of wheat from threshing machines was from 11.0 to 17.3 per cent, against 11.0 to 19.1 per cent for combined grain. The average moisture content of the grain from threshing machines was 15.0 per cent, or 0.90 per cent higher than that from the combines.

CONCLUSIONS

1. The combine threshing losses in most cases were not excessive and amounted to less than the cutter bar losses.
2. For unfavorable weather conditions as in 1928, the harvesting losses for the combine method are slightly higher than for the binder-thresher method. The difference is not large. For harvesting conditions more nearly average, it is reasonable to believe the losses by the combine method would be lower than by the binder-thresher method.
3. The windrowing system appears to reduce the trouble due to high moisture content, and to lower threshing losses in weedy grain, and also to increase the rate of harvesting under adverse conditions.

Windrow Method of Combine Harvesting[1]

By A. J. Schwantes[2]

IN MINNESOTA there was an increase from eleven combines in 1927 to forty-nine in 1928. It is evident that the percentage increase is high and therefore significant.

The windrow method of combine harvesting was first used in Minnesota in 1928. Sixty per cent of the combine owners used this method. The ready acceptance of the windrowers comes from the natural reluctance on the part of the farmer to delay his harvesting operations from a week to ten days after binder harvest time. With the windrower he can cut his grain and lay it in the swath about the time the crop would be ready to cut with the binder. The time required to dry to a moisture content low enough for safe storage will depend on weather conditions and on the stage of ripeness at time of windrowing. Figs. 1 and 2 indicate that from three to six days would be required.

The object of the studies, the results of which are represented by these graphs, was to compare the rate of drying in the windrow with the rate at which the uncut grain would ripen and dry after binder harvest time. In these studies part of each field was left uncut for the purpose of obtaining samples. Two different heights of stubbles were also studied to determine whether the height of stubble would be a factor in the rate at which the windrow would dry. Few weeds were present in fields represented by these figures. During the period between August 2 and 11 the temperature ran quite high and even. There were no periods of cloudiness or damp weather.

Fig. 1 shows the results obtained on a field of barley at Crookston that was windrowed on August 2. The moisture content of the barley at time of cutting was slightly above 37 per cent. This would indicate that the crop could hardly have been cut with binders before this time.

Height of Stubble. It is interesting to note how closely the lines representing high and low stubble windrows remain to each other, indicating that, within reasonable limits, the height of stubble does not affect the rate of drying. This same conclusion may be drawn from the curves in Fig. 2, and is further verified by data, not shown here, taken from several other fields in the same vicinity and also in other parts of the state. If the stubble is too high in proportion to the total length of the straw, the short stems with heads attached will have a tendency to drop down to the ground. The very high stubble will also be more flexible and therefore will not be as effective in holding up the windrow as the shorter stubble which is more rigid. Observations and comparisons made on a number of fields in various locations indicate that the most satisfactory height of stubble for the windrow to rest on is about one-third the total length of the straw.

Rate of Ripening of Grain. Approximately six days were required for the grain in the windrows to reach a moisture content of 14 per cent. It is surprising to note, however, that only about two and one-half days more were required to bring the uncut grain down to that point. The curves indicate that the rate at which the uncut grain ripened and dried was almost as rapid as that in the windrow. This same general conclusion is drawn from a number of other fields and for other grains as well. Fig. 2 shows that the uncut grain ripened equally as fast as that in the windrows. In this case, however, the crop had advanced slightly further at time of cutting than in the case of the barley. The wheat contained slightly more than 21 per cent of moisture when it was cut on August 7.

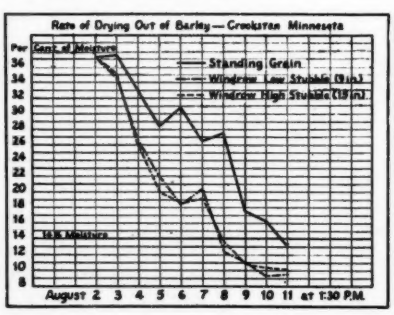
These results would indicate, that from the standpoint of permitting the combine harvester to start earlier in the season and thus making possible a longer season during which it can operate, the windrow method is not much of an advantage. In the barley represented in Fig. 1, straight combining could have begun on August 10 or 11 whereas combining from the windrow could not begin before August 8. If the wheat represented in Fig. 2 had not been windrowed, it would have been ready for straight combining on August 10 and it was impossible to combine from the windrow before that time.

Losses After Binder Harvest Time. The question of losses after binder harvest time, both in the windrow and while standing, will naturally arise. What such losses due to hail or natural shattering while in the windrow would be, is difficult to say. No data were obtained to show this. Determinations were made, however, of losses from shattering on a number of varieties at four different locations representing various Minnesota conditions. This work was done by the division of agronomy and plant genetics, University of Minnesota. Results from some of these tests at University Farm indicate that different varieties vary considerably in this respect.

On all the plots square yard samples were taken every two days beginning at binder harvest time and this was continued until the moisture content was down to 14 per cent or below. Binder harvest time was determined arbitrarily by the agronomists. The moisture content of the grain at this time was usually between 30 and 35 per cent. From seven to ten days were usually required for the crop to reach 14 per cent. If there was rainy weather during the middle or latter part of the ten-day period, the time required was longer than that. If a rain occurred very early in the period it had little effect.

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928. First publication in AGRICULTURAL ENGINEERING, authorized by the Minnesota Agricultural Experiment Station as Jaurnal Series Paper No. 832.

[2]Assistant professor of agricultural engineering, University of Minnesota. Mem. A.S.A.E.


Rate of Drying Out of Barley — Crookston Minnesota
Per Cent of Moisture
Standing Grain
Windrow Low Stubble (9in.)
Windrow High Stubble (18in.)
14% Moisture
August 2 3 4 5 6 7 8 9 10 11 at 1:30 P.M.

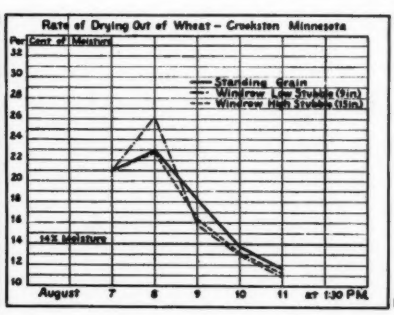
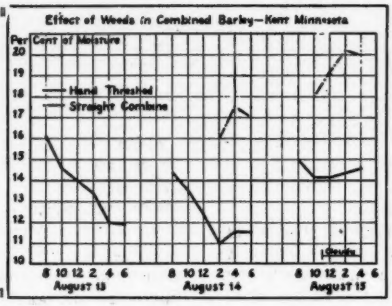

Rate of Drying Out of Wheat — Crookston Minnesota
Per Cent of Moisture
Standing Grain
Windrow Low Stubble (9in.)
Windrow High Stubble (18in.)
14% Moisture
August 7 8 9 10 11 at 1:30 P.M.

Fig. 1. (Left) Rate of drying of standing barley compared with grain from the same field in the windrow. Samples were taken at 1:30 p.m. each day. Fig. 2. (Right) Rate of drying of standing wheat compared with wheat from the same field in the windrow. Very little variation is indicated. All samples were taken at 1:30 p.m.



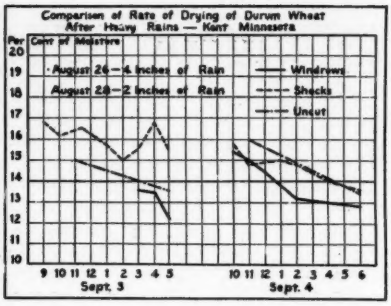


Fig. 3. (Left) Hand-threshed samples and straight combine samples taken from the same field at the same time. The hand-threshed samples contain no weeds. The difference in moisture content is due entirely to weeds. Fig. 4. (Right) Well-made windrows remain on the stubble through heavy rains and dry out quite rapidly

The following table gives some of the results that were obtained at University Farm. All yields were calculated on the basis of 14 per cent moisture.

Plot No.	Variety	Days after binder harvest time	Moisture content at that time, per cent	Yield at binder harvest time	Yield at 14 per cent moisture	Per cent of loss
1	Mindum wheat	10	13.6	48.35	40.90	18.21
2	Marquis wheat	8	14.0	42.77	36.55	17.01
3	Anthony oats	8	13.8	102.49	76.76	33.52
4	Gopher oats	6	17.8	102.44	100.81	1.61
	Same plot after rain	13	12.6		77.27	32.57
5	Velvet barley	9	15.6	53.67	44.63	20.25
	Same plot after rain	15	14.0		39.69	35.22
6	Svansota barley	6	15.4	64.60	55.48	16.43
	Same plot after rain	15	10.8		47.55	38.27

NOTE: Plots 4, 5, and 6 received rain as indicated. This added about 5 or 6 days to the time necessary for the moisture to reach 14 per cent.

Weeds and the Windrow Method. At Kent studies were made on a number of fields most of which were quite weedy. Many fields were cut with a windrower after the moisture content of the wheat or barley was below 14 per cent because of the enormous crop of weeds. In a weedy field, the situation for straight combining becomes increasingly worse as time goes on after the grain crop has once reached the 14 per cent mark. At this stage many weeds have grown almost or equally as tall as the grain and are still continuing to grow . The grain, on the other hand, will tend to bend over slightly making it necessary to run the cutter bar of the combine lower if all of the heads are to be reached. This, in turn, will bring more weeds into the thresher and consequently into the threshed grain.

Two ways in which a weedy crop may be successfully handled with a combine are by using the windrow method or by separating the weed seeds and small particles of the weed plants from the threshed grain immediately after combining. Since the latter would under many conditions eliminate the necessity of windrowing, it seems logical that considerable attention should be given to it. There seems to be no method of cleaning at present that is entirely successful in the separation of this green material from the grain. This separation should be done on the combine itself, or within a few hours after combining. These weed materials often have a moisture content of from 30 to 40 per cent and in a very weedy field the percentage of dockage in the grain will run quite high. Fig. 3 shows the results of such a situation. The presence of weed materials in the straight combined grain raised the moisture content of the mixture from 4 to 6 per cent higher than the moisture content of the barley which was hand threshed and contained no weed materials. Natural ventilation methods cannot be utilized to best advantage in grain containing a high percentage of dockage because much of this foreign material is so small in size that it fills up the spaces that would normally exist between kernels in a mass of clean grain.

Comparisons of rates of drying grain when uncut, in shocks, and in windrows were made on several fields and with several different crops at Kent. Fig. 4 shows the results of such a comparison on a quarter section of Durum wheat, one-half of which had been cut with binders and shocked in round shocks. These shocks were not capped. The other half of the field was cut with a windrower. The windrowing had been done about 10 days previous to combining and the other part of the field had been bound and shocked about twelve days before threshing. Both shocks and windrows received about four inches of rain on August 26 and two inches on August 28. On August 29, the weather was cloudy but was clear after that until threshing time.

Shock threshing was begun on September 2, just one week after the first rain. Grain threshed that afternoon had a moisture content of 18 per cent. Beginning on the morning of September 3, samples were taken from the threshing machine as well as from the combine about every two hours. The curves show that the grain in the windrow was never as wet as that in shocks. Hand-threshed samples from standing grain, that had been dead ripe for about two weeks showed that it took on considerable moisture during the night and lost it during the day, the amount dropping to nearly 13 per cent. Samples from the windrows were uniformly more dry than those from standing grain. This may be explained by the fact that the grain in the windrow could not take on as much moisture during the night.

Will the Windrow Stay Up on the Stubble? To those who have not studied the windrow method of harvesting, the question often arises as to how long and how successfully the windrow will be held up by the stubble. It was interesting to note in this connection the way in which these windrows were still held up by the stubble, allowing air to circulate underneath them, after having received about six inches of rain and having gone through a period of damp and cloudy weather for about four days.

The only case where any difficulty was encountered in keeping the windrow on the stubble was on a field that was cut on a windy day. Those rows running at right angles to the direction of the wind had been bunched together by the wind while falling from the hood of the windrower to the ground. The result was a narrow but compact windrow which had a relatively high weight per unit area and in most places was almost or entirely down on the ground.

CONCLUSIONS

While the work which was done during the past harvest season is by no means sufficient to warrant drawing any definite conclusions, the information obtained indicates that the windrower is almost indispensible when combining a weedy field; its use may lengthen the harvest season by several days; and the windrow, if properly made, will remain on the stubble for a long time.

On the other hand, indications are that straight combining may be made quite successful under normal weather conditions in the absence of weeds or in conjunction with some means of separating green weed seeds and parts of weed plants from the grain in the process of combining.

Harvesting Beans with the Combine in Michigan[1]

By E. C. Sauve[2]

AT THE conclusion of the 1928 grain harvest, we found an additional job for the combined harvester-thresher in Michigan, namely, the harvesting of the pea or navy bean. These tests, sponsored by the agricultural engineering department of Michigan State College, were made in cooperation with the Western Harvester Company which supplied equipment and men throughout the entire bean harvest.

A windrow pick-up was assembled to a No. 38 Holt combine in preparation for the tests. A number of problems were presented. To begin with, we found it necessary to reduce the cylinder speed of the combine, which was accomplished by reducing the motor speed. This change also reduced the speed of the separating mechanism, which resulted in considerable loss of unthreshed beans through the machine. There was also a considerable percentage of split beans. Later, a larger gear was placed on the cylinder shaft to reduce its speed and at the same time provision was made to maintain a normal separation speed. All the teeth were removed from the concaves and the holes left by them were plugged. This change, while partly beneficial, was not an entirely satisfactory solution.

Finally we received and installed a regular bean cylinder and bean concaves. The bean cylinder had about one-half the number of teeth found in the grain cylinder with a proportionate reduced number of concave teeth. The concave teeth for beans differed from the regular concave teeth in that they presented a knife edge to the incoming beans while the others were fairly blunt. Sieves, not adjustable, were specially made up of hardware screen to suit the size of beans threshed. After these adjustments were made, the combine was operated in the windrowed beans with much more satisfactory results.

Tests were made to determine the percentage of loss of beans with the tailings and also due to shattering. By shattering in this connection is meant the loss occasioned in the operation of pulling and raking the beans into windrows prior to the time the combine began operations. These losses were measured by first removing the straw spreader and placing a canvas at the rear of the machine in such a position that all the tailings were caught. An accurate count was then made of the beans passed over including those unthreshed in the pods. Likewise all beans having been separated by the combine were caught in a sack and accurately weighed for a count. A shattering count was made covering the area of the tests.

With this information, it was possible to calculate the percentage of loss to the total yield as follows:

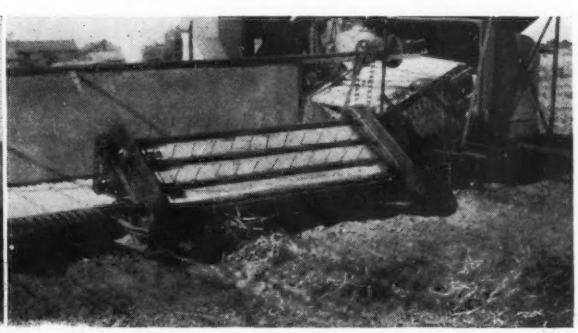
Unthreshed ripe pods	1.4 per cent of total yield
Beans passed over with tailings	2.4 per cent of total yield
Shattering	1.6 per cent of total yield
Splits	1.1 per cent of total yield
Foreign material including soil particles and small stones	1.87 per cent of total weight

The total loss registered in producing a marketable crop of beans was 6.5 per cent of the total yield. Although no definite figures are available, it is believed by experienced threshermen that this percentage is low as compared with the loss sustained in handling beans in the usual manner.

For the benefit of those who are not familiar with the usual method for bean harvesting, a few words of explanation may not be amiss. A bean puller is employed which pulls two 28-inch rows at a time and places them in a single windrow. Two or more of these windrows are put together with a side-delivery rake into a larger windrow to cure. These windrows are forked into small cocks, loaded on wagons and drawn either to the thresher or into barns. It is quite apparent that there is considerably more labor involved in this process than there would be in combining, and consequently a greater loss of beans from shattering.

In our tests two sizes of windrows were combined, four and six bean rows. The combine had the capacity to handle the four-row windrow with the tractor running in low, but there was hardly enough space for the machine to operate without crushing the adjacent windrow by the tractor wheels. Where six bean rows were raked together, this difficulty was obviated; but another difficulty arose. In heavy yields, it was frequently necessary to slip the clutch of the tractor to prevent plugging of the beans in the feeder house of the combine.

Perhaps the greatest difficulty to be overcome in the extended use of the combine in harvesting beans in Michigan is the presence of a large number of stones on many of the farms in some sections. This was our principal difficulty in Ingham County where the tests were made.



(Left) The bean harvesting outfit and crew at work. (Right) A close-up of the pick-up attachment

[1] A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2] Assistant professor of agricultural engineering, Michigan State College. Assoc. Mem. A.S.A.E.

Several times, in spite of close watching, stones enveloped in the raked windrow, would enter the feeder house, breaking slats on the feeder canvas. The replacement of thse slats occasioned some delay. We experienced much better success when a man with a pitchfork preceded the combine raising the windrow and dislodging any stones clinging to the vines. While the pick-up used did a remarkably good job, it was found desirable to have one man follow the combine forking into the machine the vines it left.

These experiments would lead to the conclusion that a fair job of separation can be attained with the regular combine equipment with minor changes and adjustments. For beans it is quite evident there should be a wider spacing between the cylinder teeth and the concave teeth. An adjustment which would make possible a quicker change from small grain combining to bean combining would be desirable from the standpoint of the user who produces a variety of grain on comparatively small acreages. Where large acreages of beans are handled, it would seem advisable to substitute the special bean cylinder and concaves for the regular small grain equipment.

A view which shows the man preceding the combine, forking the windrow to separate it from stones, and the man following the pick-up catching any stalks which it missed

No attempt was made to compare the cost of handling beans by the old and new methods.

Harvesting Soybeans with the Combine[1]

By I. D. Mayer[2]

THAT soybean growers have recognized the advantages of the combine for harvesting this crop is demonstrated by the fact that over two-thirds of the 90 combines now in Indiana were purchased primarily for soybeans. Combine owners desiring to do custom work can usually engage all the acreage possible to cut during the season. This willingness of farmers to wait until a combine can harvest their beans is largely due to the fact that the combine puts a larger percentage of the beans into the bin than any other method of harvesting commonly practiced. While field losses by the mower or binder and threshing machine method of harvesting entails losses of from 15 to 45 per cent of the beans grown, the losses from the combine harvester rarely exceed 10 per cent.

In addition to saving more beans, combining usually results in a higher quality product. The moisture content of samples of soybeans taken from stationary threshers varied from 11.6 to 26.5 per cent, averaging 16.9 per cent, while beans from combines during the same period had moisture contents of from 10.2 to 15.4 per cent, averaging 12.5 per cent. In this connection it might be interesting to note that on the same day and in the same field of variety plots, the moisture content of the different varieties varied from 14.0 to 16.6 per cent. In 1927 germination of beans from combines averaged 94.5 per cent while those from threshing machines averaged 95.5 per cent.

The quality of the threshing done by the combine has been satisfactory in most cases. However, during the past season there has been an unusually large percentage of split beans. This condition has been more common with combines and stationary threshers than with the regular bean hullers. We still find a few operators trying to thresh soybeans without installing the special attachments.

Probably the second most important advantage of the combine in harvesting soybeans is the low cost of threshing. Usually the entire harvesting cost with the combine is about equal to the thresherman's charge for hulling with the stationary machine. When all costs are considered, including interest on investment, taxes, etc., we have had harvesting costs with the combine as low as 10 cents per bushel for soybeans. The most common costs, however, are 20 to 25 cents per bushel.

In spite of all of the advantages noted, there were this year a number of fields of soybeans which were intended for the combine but which have been left standing or have been plowed under. This was due primarily to the excessive growth of weeds. In most cases the beans had fallen down somewhat thus adding to the difficulty of getting the material upon the platform. In several instances where weedy beans were being cut reels were broken by the tangled mass of weeds and beans becoming wedged upon the platform. An easily adjustable reel would have been of considerable assistance under these conditions. In tall weeds a larger reel would function better. In fields in which weeds are thick it is necessary to travel slowly with the combine to avoid slugging the cylinder. Under such conditions a ground drive for the reel would be a decided advantage. It would not only relieve the strain upon the reel but would reduce the shattering of beans by the reel bats.

Under most conditions, the use of windrow and pick-up attachments have not been considered desirable for harvesting soybeans for the additional handling of the beans will increase the losses. In fields in which the ripening is very ununiform, the use of the windrow and pick-up attachments may make earlier harvesting possible. When the field is to be sown to wheat, the use of the windrow and pick-up might be desirable.

In the past seasons combining of broadcast beans has been more satisfactory than beans in rows due to the uneveness of the ground caused by cultivation. It has also been claimed that beans in rows had their pods closer to the ground than broadcast beans thus causing a greater cutter bar loss. In spite of these handicaps, beans in rows were easier to combine during the past season because of weeds in the broadcast beans. In some weedy fields, it was possible to harvest the soybeans by going over each swath twice, first with the platform raised to cut only the weeds and the second time over with the platform down to get the beans. This, of course, increased the cost of harvesting somewhat.

In spite of these difficulties, the combine still offers the most satisfactory means available for the harvesting of soybeans.

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[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Assistant agricultural engineer, Purdue University Agricultural Experiment Station. Assoc. Mem. A.S.A.E.

Cleaning Grain Harvested with the Combine[1]

By Robert H. Black

NEARLY all of the grain harvested with combines in the spring wheat area of the central Northwest contains weeds. Weeds are also found to a lesser extent throughout nearly all of the areas in the United States and Canada in which combines are operated.

A few of the weeds found in the grain fields are ripe at the time of harvest. The majority of the weeds, however, do not ripen until after the grain is harvested, although seeds have formed in most of the immature weeds. These seeds in the immature weeds contain high percentages of moisture, which, depending upon the relative maturity of the weeds, ranges from 20 to 60 per cent. This percentage of moisture also varies with the season, locality and the variety of the weeds.

As reported at the meeting of this Division last year, much of the moisture transfers from the weed seeds to the threshed grain within 24 hours, and further moisture transference occurs until the moisture in the weed seed and in the grain is approximately equal within two or three weeks.

If these immature weed seeds are stored with the combined grain the excess moisture in the weed seeds rapidly transfers to the grain and in most cases, where any considerable amount of high moisture weed seeds are present in the grain, the grain becomes damaged in storage.

If the weed seeds are not removed promptly, sufficient damage may occur to the grain to more than offset the savings possible from the use of the combine. Since the weedy condition is general throughout the spring wheat area, it is evident that, if the direct combine method of harvesting is to be a success, proper methods of cleaning must be available to prevent lowering the value of the crop.

The windrow method of harvesting, in which the grain is cut and put in a swath or windrow before being picked up with the combine, permits the drying of the weeds several days before threshing and removes much of the moisture from the weed seeds; this extra handling incurs an additional expense and each extra handling also increases the loss of grain. Even after windrowing the weed seeds should be removed from the grain before storage, because some kinds of weed seeds impart commercially objectionable odors to the grain and because they also prevent proper circulation of air through the grain. Most of the combines in the spring wheat area during 1928 were equipped with cleaners which removed about half the weed seeds which had dried out in the windrow.

Unfortunately in direct combining, the weed seeds which contain the most moisture are usually of approximately the same diameter as the wheat kernels, but many of these high moisture weed seeds are shorter than the wheat kernels. Such weed seeds as lambsquarter, sweet clover, wild buckwheat, and rag weed retain their hulls during the combine threshing operation unless they are fully matured. When these weed seeds are mature and dry, they are much smaller than the grain kernels and most of them are easily cleaned out.

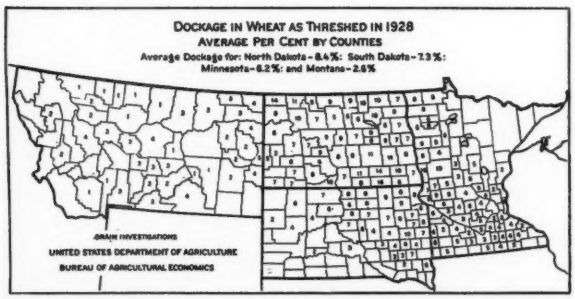
Several grain cleaning attachments to existing combines were used cooperatively with the U. S. Department of Agriculture in 1928 in an attempt to remove these larger weed seeds which contained the high percentages of moisture. The results secured were not entirely satisfactory, but information secured in 1928 indicates that there are possibilities which should be developed by further research work. One device which was effective in removing such high moisture seeds was operated on sixty lots of wheat which contained an average total dockage of 7.5 per cent, of which the small seed dockage ranged from 2 to 17 per cent; the average moisture in the sixty lots of wheat containing the dockage was 15.6 per cent, which caused the wheat to grade No. 4 and make it unsafe for storage. The average moisture of the wheat after being passed through the cleaner was 14.4 per cent which would permit the wheat to grade No. 2 and would make it worth 8 cents per bushel more than before the cleaning because of the lower moisture content and improvement of the grade. Most of this recleaned wheat was then also in condition for safe storage. At the beginning of the harvest the weed seeds removed had an average moisture content of 40 per cent. At the end of the season after the first light frost the average moisture content had decreased to 19 per cent; the average moisture content in the weed seeds removed during the entire time was 31 per cent.

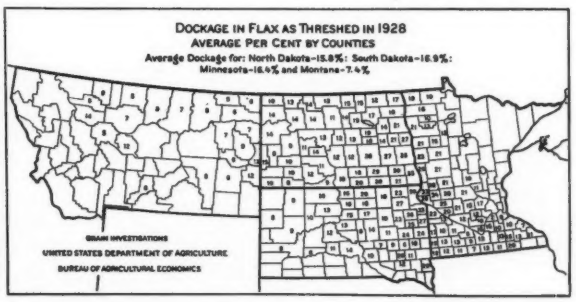
One device was partly successful in removing Russian thistle.

Another method of removing the green weed seeds from the wheat as practiced by several farmers in the spring wheat area is to clean the wheat and other grains with the fanning mill or other grain cleaning device within 24 hours after harvest. Even when cleaning is delayed over night considerable of the moisture transfers from the weed seeds to the wheat. The complete transference of excess moisture does not usually occur for about one week after cutting, although one-half the moisture usually transfers during the first 12 to 24 hours. Wheat containing Russian thistle is particularly adapted to this method of cleaning because after the wheat has stood for a few hours, usually over night, the Russian thistle heads and spines can then be blown and screened out of the wheat so that

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]In charge of grain cleaning investigations, U. S. Department of Agriculture. Mem A.S.A.E.


DOCKAGE IN WHEAT AS THRESHED IN 1928
AVERAGE PER CENT BY COUNTIES
Average Dockage for: North Dakota-8.4%; South Dakota-7.3%;
Minnesota-6.2%; and Montana-2.6%
GRAIN INVESTIGATIONS
UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS


DOCKAGE IN FLAX AS THRESHED IN 1928
AVERAGE PER CENT BY COUNTIES
Average Dockage for: North Dakota-15.8%; South Dakota-16.9%;
Minnesota-16.4% and Montana-7.4%
GRAIN INVESTIGATIONS
UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS

the wheat can be stored safely, if sufficiently low in moisture content.

CONCLUSIONS

1. Weed seeds should be removed before the grain is placed in storage.

2. Part of the weed seeds can be removed with present types of grain cleaners available for combines, if the windrow method of harvesting is used.

3. Straight combined grain may be cleaned with present available equipment within a few hours after the grain is cut.

4. Further grain-cleaning research is desirable to devise means of removing more of the high moisture weed seed at the combine, so that more of the grain can be combined directly without the expense of windrowing.

Effect of Weather Conditions on the Moisture Content of Standing Grain[1]

By C. O. Cromer[2], J. S. Cobb[3] and H. B. Josephson[4]

THE departments of agronomy and farm machinery of Pennsylvania State College cooperated during the harvest season of 1928 in studying the daily and hourly variation in the moisture content of wheat and oats before combining.

It was desired to ascertain, if possible, the period of the day during which the grain could be safely combined. From the studies made the following points were deduced:

1. There was a steady decrease in the moisture content of wheat and oats from nine o'clock in the morning until six or even seven o'clock in the evening even though the relative humidity began to increase after about two o'clock in the afternoon.

2. During different days the grain lost from three to eight per cent in moisture content depending upon weather conditions. This loss was partially or wholly taken up the following night depending upon the condition of the atmosphere.

3. The daily loss in moisture content varied inversely with average daily relative humidity.

4. The moisture content of the wheat increased from three to five per cent over night just from heavy dews. A half inch of rain at night increased the moisture content of the grain 8.3 per cent.

5. No definite hour in the morning for starting the combine is indicated since it depends entirely upon weather conditions.

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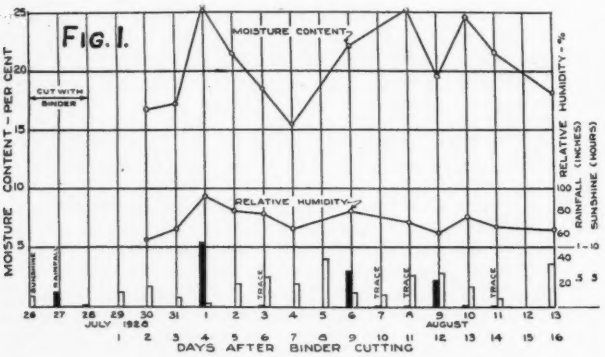
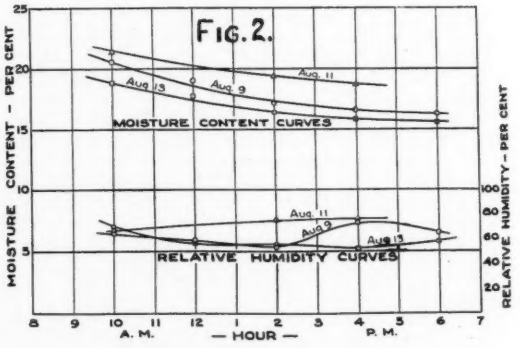
[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

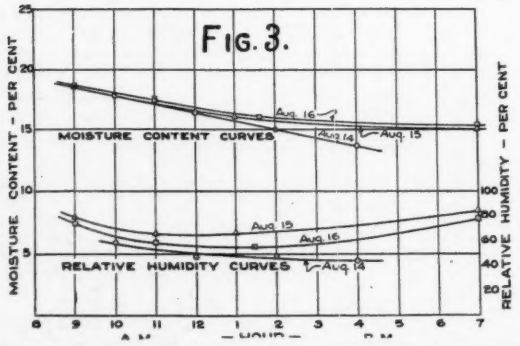
[2]Professor of agronomy, Pennsylvania State College.

[3]Assistant professor of agronomy, Pennsylvania State College.

[4]Agricultural engineer in charge of farm machinery research, Pennsylvania State College. Mem. A.S.A.E.







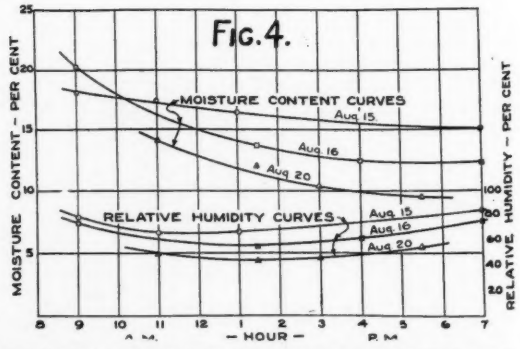


Fig. 1. Daily variation in moisture content of wheat samples taken from Mitchell field at 11:00 a.m. Fig. 2. Variation in moisture content of wheat in the same field during days of good harvest weather. Fig. 3. Variation in moisture content of wheat during good harvest weather. Fig. 4. Variation of moisture content of oats during good harvest weather

The Combine in the Prairie Provinces[1]

By E. A. Hardy[2]

WINTER set in early in November last year, so that thousands of acres of the 1927 crop were not threshed or combined until the spring of 1928. It was interesting to note the condition of the grain as it was threshed from the stook (shock) as compared with the grain which lay out in the fields under the snow.

The spring of 1928 was ideal as far as conditioning the unthreshed grain was concerned. There was very little thawing and freezing until the snow went off, after which the weather remained cold with practically no rain. During the latter part of April and May dry hot winds prevailed until in many sections spring seeding suffered from soil drifting and drought. The result was that after the 1928 crop was seeded the grain which had not been harvested was either combined or threshed.

The stooked grain suffered considerable loss from mice during the winter and spring. It was hard and dry and of good color, and in many instances graded higher than grain threshed during the wet 1927 fall. The grain harvested by the combine had not been molested by the mice but had bleached badly. It was hard and dry so that it threshed and handled nicely. The grain graded practically the same as the fall before.

The combine demonstrated its ability to pick up down grain during the spring operations. Some difficulty was experienced in picking up stones. It was also difficult to get the matted straw down on the table canvas so that it would be taken to the feeder evenly. Where large bunches were delivered to the feeder some difficulty in clogging was experienced.

Condition of the 1928 Crop. The spring of 1928 was not ideal for obtaining uniform germination. Only those who seeded early and deep obtained uniform germination and growth. The vast majority of the 1928 crop germinated about 75 per cent when seeded in April and May, and then in June after the heavy rains, the remaining 25 per cent germinated, thus developing a crop which was not at all suitable for combine harvesting. June and July were extremely wet months, producing an enormous growth of straw and apparently wonderful prospects for a record grain crop. The first part of August was hot and dry thus hastening the ripening of the crop until about August 20, when the weather changed. During the nights of August 22, 23 and 24 there was as much as fifteen degrees of frost all over Western Canada.

At the time of the frost only a small percentage of the crop was cut. Considerable areas were sufficiently ripe so that the grain was not damaged, but as a whole more than 75 per cent of the wheat was damaged by the frost.

During the last two weeks of August the grain ripened and dried very slowly. The high percentage of green grain in the stooked grain delayed threshing so that often grain was tough even after six weeks of standing in the stook. Grain which had been swathed seemed to lie on the stubble much longer than had been anticipated, and did not dry sufficiently for combining until from ten days to three weeks, depending somewhat upon the condition of the grain when cut.

There was very little grain harvested by straight combining in August because of the green grain resulting from the late germination. Many fields were left standing until October before the green kernels were not detrimental to the grain.

Increase in the Use of the Combine. In spite of the fact that the irregular condition of the grain crop did not indicate satisfactory conditions for the use of the combine for harvesting, the increase in the use of the combine in the prairie provinces was far beyond all expectations. It was impossible for the machinery companies to supply the demand when the harvest started.

Table I indicates the annual increase in combines sold, and the total number of machines used in the prairie provinces during the 1928 harvest:

TABLE I. Combine Sales for the Last Three Years

Year	Manitoba	Saskatchewan	Alberta	Total
1926	2	148	26	176
1927	21	382	195	598
1928	166	2301	1046	3513

Total in the prairie provinces since 1922—3530

Swather Sales in the Last Two Years

1927		16	25	41
1928	132	1087	713	1932

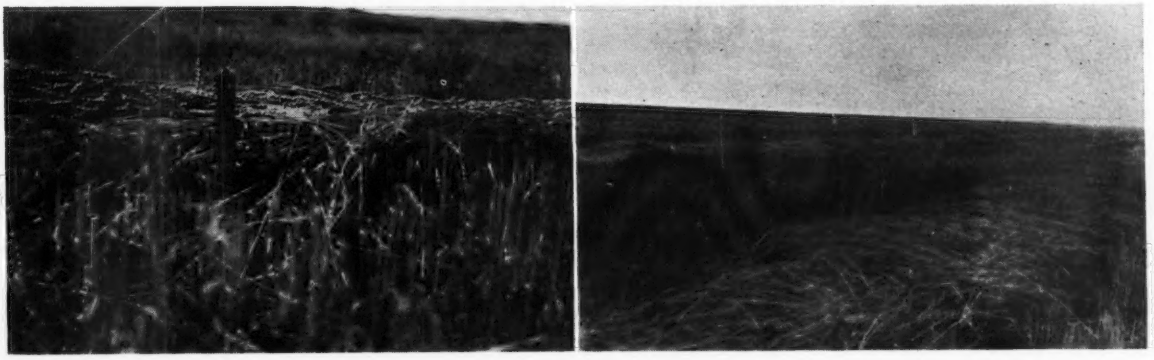
Total in the prairie provinces—1973

The Swather or Windrow Harvester. The swather was first used in Saskatchewan last year. A great deal of credit must be given to the engineers and experimental departments of the farm machinery manufacturers for the success of the swather when built on such short notice with so little time for experimental work.

As a whole the swathers did reasonably good work. Some of them were not built strongly enough. Others

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Professor of agricultural engineering, University of Saskatchewan. Mem. A.S.A.E.



(Left) Grain in the windrow well supported by the stubble. (Right) A field cut by the swather or windrower

were so arranged that the stubble was tramped where the swath was discharged so that the stubble did not support the swath. Some of the swathers did not spread the swath enough when placing it on the stubble, resulting in considerable quantities of grain settling down to the ground. In some the grain was carried too high before being discharged, thus pounding the stubble down with the heavy weight of grain and straw. There was not room enough to make the turn at the corners with some of the swathers, and the grain was trampled down into the stubble when turning. Also difficulty with the straw carrying back under the canvas and causing the canvas to stop seemed to be common. Some complained about chains and gears wearing out, and yet after all was said and done, practically all of those using the swather claim that they can be made to work, and that they are necessary with the combine in many areas in the prairie provinces.

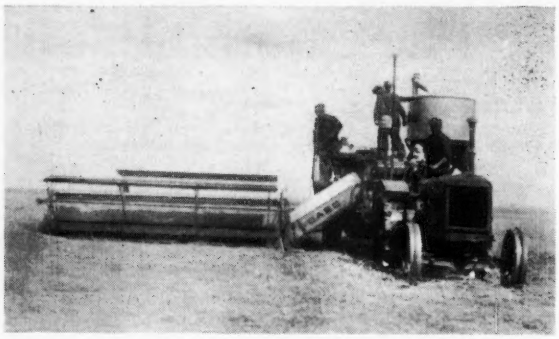
Our 1928 crop was not a complete test for the use of the swather. Several points in its use were determined, however. Where ripe and green grain was cut and placed in a swath together the green grain dried before it ripened in the fields where the grain was left standing for straight combining. Where weeds were present in the crop, the weeds were dried so that they were separated from the grain and carried through with the straw. Where large areas per combine were to be harvested, the season during which the combine could be used was lengthened. Where green spots were present in the field the grain cut by the swather usually dried so that the grain was not filled with green kernels as when straight combining.

The continued dry weather did not make it possible to note what would happen to the poorly formed and supported swaths of grain during wet weather or snow, as is so often experienced in the prairie provinces during harvest. Thus the manufacturer and the farmer must not consider the success of the swather in the 1928 crop as indicative of what is to be expected each year. A great deal yet remains to be done before the swather will be entirely satisfactory.

Pick-up Attachments. When the grain in the swath became dry enough to thresh, it was necessary to pick it up and deliver it into the feeder of the combine. At first one would not think it difficult to provide an attachment to the combine which would do this without too much grief. The 1928 crop was a good test of the action of the pick-up and also the capacity of the combine. The straw was long and heavy. It was cut fairly low in order to get all of the heavy heads which seemed to hang low after the frost. A swath consisting of straw from 2 to 3 feet long, lodged on top of and down into stubble from 12 to 24 inches long was quite a common condition. The straw was heavy enough for a 40 to 50-bushel crop. The farmer had hopes of pulling the combine and pick-up at least at three miles an hour so that from 35 to 60 acres per day might be harvested. The result was a great disappointment. In many instances the combine could not handle the straw even when the tractor was operating on low. This was due largely to the fact that the pick-up did not deliver the straw onto the canvas in such a way that a continuous flow of straw was delivered to the feeder. There was a tendency for the straw to slide over the canvas and bunch until sufficient weight was collected to carry the straw to the feeder. Usually so much straw coming into the feeder would plug up the machine, throw off the belt, or stall the engine. In many instances a man was stationed on the back of the pick-up table to fork the grain onto the table and into the feeder.

The pick-up attachment is usually quite heavy and must be carried by the table frame or attachment frame. The additional weight must be balanced in some way. In several designs the balancing seemed to have been overlooked. Also the strength of the frame supporting the attachment was not sufficient to prevent sagging.

Stones were picked up by some of the attachments and run through the combine. The farmer must keep the fields free from stones if the pick-up is to be entirely safe. Also the manufacturer must use a tooth which will not pick up stones.



Combining wheat in Stewart Valley, Saskatchewan, in May, 1928. This wheat was snowed under before it could be harvested in the fall of 1927

It was found necessary to comb the ground to get the grain which had fallen down to the ground in between the stubble rows. Many of the pick-up attachments could not pick up grain which was lying on the ground lengthwise in between the stubble rows. Some of them were not built strongly enough to stand the pressure of combing the heavy stubble. Some of the combine users found that the pick-up attachment was not put together rigidly enough so that it would operate for any length of time without rattling to pieces.

The pick-up attachment was by no means a failure. There were over 2000 pick-up attachments used on several hundred thousands acres of crop. The crop is all picked up and threshed. The farmers have done a lot of experimental work in cooperation with the manufacturers, and are glad to do so, providing the cost of harvesting can be reduced.

The swather and pick-up attachment are here to stay. There are many districts where nearly all of the grain will be swathed, picked up and threshed by the combine. There are many districts in which a portion of the crop will be swathed and picked up, and the rest will be straight combined, and there are other areas, especially in Saskatchewan, where the grain will all be harvested by straight combining.

Farming for the Combine. The Canadian farmers realize more and more the importance of linking up the seeding and tillage of the farm with the harvesting methods. They realize that not only must the manufacturer build machines for the crop, but that they must build the crop for the machine.

Those who have been using the combine during the past few years have demonstrated the value of using pure seed which has uniform characteristics, ripens early, and withstands the tendency to shatter; of preparing the seedbed so that the combine, swather and pick-up can be operated without picking up stones, roots and soil when it is necessary to run close to the ground; of seeding early and deep enough to insure germination and resistance to drought. They have also shown that insect pests such as the sawfly, wire worm or cut worm are detrimental to the crop and make harvesting with the combine difficult, and that a careful study of plowing and packing the land with reference to the control of such pests has been valuable; and that the successful combine user studies the time to cut the grain with either the swather or straight combine so that the grain will be dry and of the best quality.

The method of harvesting with the combine is here to stay. Those most successful are planning the seeding, harvesting, and marketing of the crop so that each operation prepares for and harmonizes with the other.

The Combine in Saskatchewan[1]

By J. K. MacKenzie[2]

OUTSTANDING in the development of harvesting methods, in 1928 apart from a vast increase in the number of combines used, was the introduction of the swather or windrowing device and the pick-up. These auxiliaries to the combine are designed to increase its utility. Whether they do so or not is still a debatable question, but certainly they were a pronounced factor in selling the combine. Many farmers, who refused to let their crops stand in the field until ready for straight combining, were attracted by the idea of the swather. They could commence operations just as early with the swather as with the binder, and apart from any financial benefit derived from its use it gave them something to do at a season when habit and custom demanded activity.

The harvest season of 1927 was particularly unfavorable. Considerable areas of shocked grain stood in the fields over winter. Some fields designed for the combine were not harvested until May of 1928. The grain harvested by the combine in May was bleached almost white but was hard and dry. Shocked grain was not bleached to the same extent, but considerable loss was occasioned by mice. In at least one case swaths lay on the ground over winter. These were picked up and threshed in May. The grain, although hard and dry, was badly bleached and some loss was sustained by reason of the impossibility of picking up all the heads.

At the Dominion Experiment Station at Swift Current, Sask., an attempt was made this season to compare the relative efficiency of the straight combine, the swather and the header-barge. The last is a species of dumpcart which receives the headed grain from the header. The grain is dumped on the field in the form of small stacks of approximately 6x6x14 feet and left in the stack until dry. The combine, with the knife and reel removed, was used to thresh the stacks. The header-barge and swather were operated at intervals beginning with the normal date of binder-harvesting and continuing until the grain was dry enough for straight combine harvesting. Moisture determinations were made of all grain harvested by the swather and header-barge at three-day intervals extending from the day of cutting until that of threshing.

In the case of the first cutting by the header the following shows the rate of decrease of the moisture content:

August 29	35.3 per cent
September 1	19.14 per cent
September 4	17.38 per cent
September 7	15.23 per cent

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Assistant to superintendent, Dominion Experiment Station, Swift Current, Sask. Assoc. Mem. A.S.A.E.

A header barge harvesting a light crop of wheat

In order to put the header-barge to a more severe test it was used on another field where the crop, in addition to being very green, was badly infested with green pigweed. The moisture content on the day of cutting was 48.34 per cent. Three weeks later the stacks were threshed and the moisture content of the grain was 14.41 per cent.

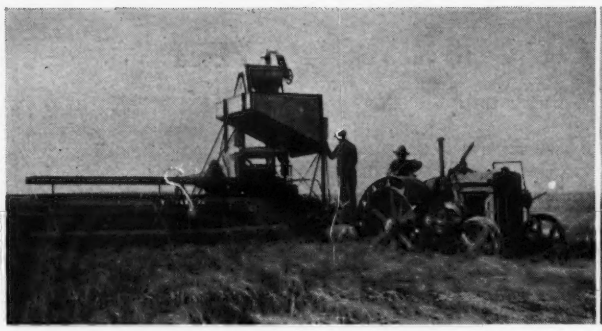
The most outstanding result was that the swathed grain, and particularly that which was swathed at the normal time of binder harvesting, did not dry out any earlier than did either the standing grain or grain in the stook (shock). It does not appear from the foregoing figures that the use of the swather in this case advanced the date of threshing with the combine to any marked extent.

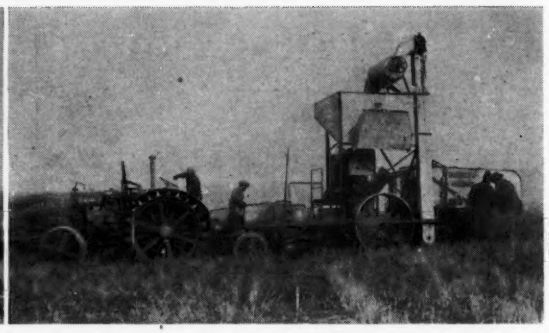
Owing to the peculiarities of the spring season, there was a great amount of uneven germination in all grain crops. This resulted in an excessive degree of uneven ripening. It was hoped that the use of the swather would overcome this disability. The green portions of the crops swathed did not dry out any earlier than those in the standing grain. Neither standing grain nor swathed grain suffered any marked damage during the waiting period as the weather was unusually fine and dry. The growth of straw was considerably heavier than that of a normal year, hence the amount of green weeds was so small as to constitute no serious impediment to straight combining. In general it may be said that the season was not such as to allow for a severe test of the merits of the swather except in regard to the matter of speeding up the operation of the combine by reason of an earlier start. Owing to the necessity of leaving the grain in the swath for upwards of two weeks, the greater portion of the initial advantage in time-saving was lost. In addition the extra cost of swathing, amounting to as much as eighty cents per acre, and the inability of practically any make of combine to attain a speed of over two miles per hour when picking up the heavy swaths, has had a sobering effect on the majority of the operators of swathers.

In the districts where Marquis wheat is the principal crop, the value of the swather is still doubtful. It may possibly be useful even in the Marquis wheat districts when used to a limited extent on weedy fields and where uneven ripening prevails. It is unlikely that it will be used so extensively by the individual farmer in succeeding years. Where oats, barley and fall rye are extensively grown as well as varieties of wheat more prone to shattering than Marquis, the swather or some such auxiliary to the combine is necessary if combines are to be used.

The header-barge showed up well in the past season. Fields where ripening was particularly uneven and fields infested by green weeds were successfully harvested by the header-barge. The stacks dried out perfectly, the grain when threshed was of good color and the grades obtained compare favorably with those obtained for binder-cut grain, straight-combined grain or swathed grain. There still remains the possibility of heavy rains of considerable duration wetting the stacks to the bottom. This happened at Arrowwood, Alta., in 1927. Those stacks had to be scattered on the ground. Apart from this possibility there seems to be nothing to prevent the use of the header-barge as an auxiliary to the combine, either in conjunction with the swather or in its place.

Cost of Harvesting with the Header-Barge. The twelve-foot header maintained an average speed of 1.5 miles per hour when due allowance was made for the time required to dump the barge. One man and six horses





(Left) Straight combining in lodged wheat. The yield was 34 bushels per acre. (Right) Threshing header barge stack with a combine

were used on the header and two men and two horses on the barge. The header harvested 2.18 acres per hour at an average cost for man and horse labor of 71 cents per acre.

As four horses were able to draw the combine from one stack to the next, the cost of threshing the stacks is somewhat less than the cost of either threshing swaths or straight combining. In a 15 bushel crop there was one stack per acre. The average time from the beginning of threshing on one stack to beginning on the next was less than eight minutes. Therefore, two men were able to thresh the stacks on seven and one-half acres in one hour. In a thirty-bushel crop only half that area could be threshed in one hour. Evidently the removal of the knife and reel gives the combine motor considerable surplus power for threshing purposes. At no time was the machine in danger of stopping although two men were throwing the headed grain on the combine table.

Comparative Losses of Wheat in Harvesting and Threshing

Swather and Combine

	Lbs. per acre
Grain lost behind swather knife	6.7
Grain left in the swath by pick-up	10.1
Grain thrown over by combine	8.18
Total loss	24.98

Gross yield, 33.85 bushels per acre
Per cent lost, 1.23 per cent

Straight Combine

Grain lost behind knife	14.68
Grain thrown over by combine	9.30
Total loss	23.98

Gross yield, 34.2 bushels per acre
Per cent loss, 1.16 per cent

Header-Barge and Combine

Grain left on ground by header	24.36
Grain lost at stack	3.11
Grain thrown over by combine	5.75
Total loss	33.22

Gross yield, 33.12 bushels per acre
Per cent lost, 1.67 per cent

Binder and Separator

Grain lost behind binder knife	16.52
Grain lost in stooking and around stook	22.23
Grain lost below bundle carrier	17.61
Grain lost on bundle rack	5.69
Grain lost in separator	11.32
Total loss	73.37

Gross yield, 34.18 bushels per acre
Per cent loss, 3.58 per cent

The Swather and Combine in Oats. A seven-acre field of oats was divided into two equal parts. One part was swathed on August 20 and threshed on August 31. The remainder was harvested with the straight combine on September 26. The entire crop was clean, uniform and stood up well. The moisture content of the swathed portion was 21.2 per cent when swathed and 8.8 per cent when threshed. The straight combined portion had a moisture content of 8.13 per cent when threshed. The swather and pick-up left 12.36 pounds of grain per acre on the ground. The straight combine left 57.2 lbs. It should be noted that the greater portion of the swather loss was occasioned by one swath falling partly in a deadfurrow in which the pick-up was operated with difficulty. Over the remainder of the swathed portion of the field the loss was almost zero. This would indicate that oats sustain a much greater loss from shelling while waiting for the straight combine than does Marquis wheat. The same is equally true of barley and fall rye.

Questionnaires on the combine were sent to six hundred operators in the prairie provinces. Up to November 30 two hundred and forty-one were returned. Of this number 44 per cent of the machines were used as straight combines entirely; 36.5 per cent were used partly as straight combines and partly with the swather and pick-up; 19.5 per cent were used entirely with the swather and pick-up. The total acreage harvested by the 241 machines was 148,469 acres which is an average performance of 616 acres for each machine.

In width of cut the combines ranged from eight to twenty feet. Assuming that 616 acres is the average performance for all combines in Western Canada, then the total area harvested by this means in 1928 was 2,901,360 acres. This is 8.37 per cent of the total area in grain crops. It is evident that the combine is here in sufficient numbers to have a marked effect on harvesting.

A combine picking up a heavy crop from the windrow

Engineering Developments in Combines[1]

By John Mainland[2]

COMBINES have reached a stage where development in them will be slow in the days to come. In a meeting of this Society not so very long ago, I heard the prediction that tractors would revert to a common type, "the survival of the fittest." We have all seen that process take place and have seen the freaks disappear and some of the so-called freaks of other days force their better qualities to the front.

The harvester-thresher is at that stage today and already the reversion to a common type has set in. If this is true, the development of the combine will slow up as its usefulness increases, and the use of the combine has only begun.

The latest off-shoot of the combine has spread itself all over the land so fast that the spread of the combine was slow in comparison. That is the swather and its twin, the pick-up. I believe there never was such a demand for a farm machine developed in one year as sprang up less than a year ago for these two implements, and never was a demand met so promptly by the makers of farm machinery. We all know more about these two late arrivals today than we did last spring when we were doing everything in our power to meet the demand so suddenly placed before us.

I can only touch on some of the high points that showed up on these latest means of harvesting grain. We found that while a cutter bar and a sickle on a combine would do good work in straight combining the same cutter bar and sickle was not nearly so good on a swather. Those of us who are ancient enough to have swung a cradle can remember how easy it was to cut green grain. I am sorry to say a swather does not respond in the same manner when it strikes a green spot. The swather pulls harder in green than in ripe grain, and the wheel slipping increases (I am speaking of the ground-wheel-driven type.) We found that the sickle speed should be faster in a swather than the combine requires. Of course, in a swather driven from the ground wheel, the sickle speed increases in proportion to the speed of travel but this does not seem to be sufficient.

We tried a sickle crank speed of 313 r.p.m. when traveling at three miles per hour, and found this too slow for green grain but fast enough for ripe grain. When the travel was increased to four miles per hour, the sickle crank speed was then 417 r.p.m. but still too slow to properly cut green grain at this rate of travel. We found better results with a sickle speed of 350 r.p.m. at three miles per hour. This gave us a sickle speed of 466 r.p.m. at a speed of four miles. The necessity of ledger plates on the sickle guards was also apparent when cutting with a swather. Cutting the grain green makes the ledger plates more necessary than in cutting more mature grain. Another reason they are required is that often the stubble is cut shorter, causing more grass and weeds to be cut and making the work harder on the sickle and guards.

After the grain is cut the next problem is to lay the swath in the proper shape. I have often heard the thought expressed that the straw should be laid at an angle with the path of travel of the machine and was of the same opinion until we got to picking it up. Then we found that we got best results with the grain laid straight in line. More important than the line the grain is laid in, however, is the way it is held up on the stubble. First, the point of discharge from the drapers cannot be too high or grain, wheat especially, will tend to fall head first and stand on end in the stubble. The windrow should not be laid too compactly, or it will not allow the wind and sun to do their work in curing and drying the grain. Most important of all, the windrow should not be laid on the ground or in a wheel track where the stubble is broken down so that it will not hold the grain up. The way the grain is laid on the stubble by the swather affects in a very large measure the work of picking it up. A poor pick-up may work successfully in a well-laid windrow and a very efficient pick-up do poor work when the windrow is poorly laid. Of course, the drying process is hindered also when the windrow comes in contact with the ground as the air cannot circulate underneath it.

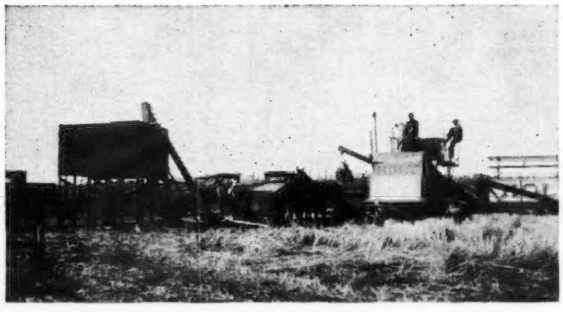
In addition to the points I have mentioned there are some mechanical points that come up. The power required to drive the sickle is greater in a swather than in the combine and requires a proportionately stronger driving mechanism. In driving a swather from the bull wheel, loose or sandy ground has to be contended with and this brings up the question of spade lugs and associated problems that we have only considered in connection with the tractor heretofore.

The pick-up is just what its name implies. It has to pick the grain and deposit it on the header draper to be fed to the combine. As we have stated before, the work of the pick-up is simplified greatly if the windrow is laid well up on the stubble so that the pick-up rake fingers, or whatever you call them, do not have to scrape the ground. The danger of going low is much greater where the ground is stony, because if a stone is hit by a pick-up finger it is possible for the stone to roll on the windrow, and if it does, it is liable to be carried up with the grain and go through the combine. If this happens, you stop to make repairs, as the combine usually is a poor rock crusher. With a well-laid windrow there is practically no danger of picking up stones. The next trouble we saw with pick-ups was in not picking up the windrow when the fingers first came in contact with the straw but rolling it ahead once or twice and then taking the whole bunch at once. This action does not give the thresher part of the outfit the best chance to do its work.

The best work seems to be done by a pick-up when the speed of the grain over it is the same as the speed of travel over the ground. If this is true, then there is a relation between the speed of travel and the revolutions per minute of the pick-up which should not be lost sight of. Some pick-ups are driven from a ground wheel to maintain this relation. The pick-up should discharge the grain in the proper manner on the header draper, or there will be trouble feeding it properly to the cylinder to be threshed. This part of the

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Engineer, Advance-Rumely Co. Mem. A.S.A.E.



Complete outfit for bulking wheat from a combine in the Palouse region

operation is quite important in order that the machine may have a chance to do its best work. Another feature which we noticed in the field the past season was the effect the wind had on the working of the pick-up. We know of cases where the work had to be stopped until the wind went down on account of it blowing the grain back after it had been picked up.

If the grain is not too heavy or long, the problem of picking up grain is comparatively simple. With long tangled grain it is more complex, especially with stiff weed stems mixed with the straw; not that it is harder to pick up from the ground, but then it is more difficult to deliver so the header draper will handle it properly without bunching or blocking.

We look for a big improvement in the work done by both the swather and the pick-up the coming season, as last season the time available for their development was short. Not only will the improvement come from better design in these machines but the operators will have better judgment in handling them in the future. With better machines better handled there will result a big improvement in this type of harvesting.

We think that the windrow method of harvesting grain should not be used where it is not necessary, but realize that in many cases this method must be employed if the combine is to become the general means of harvesting grain on this continent. The saving that has been and will be made by the combine leaves no doubt in our minds but that this method will continue as a means of harvesting grain.

Progress in Grain Drying in New York[1]

By Howard W. Riley[2]

TO THOSE of us who are familiar with the grain-growing conditions in New York state and who are endeavoring to look forward into the future, there seems to be a possibility that there may come a time when the farmers will be ready to pay the threshing charge necessary to secure the services of a custom thresherman who will be prepared to "combine" the relatively small areas of grain that are grown, and then dry in his portable drier the threshed grain, delivering it in an absolutely safe condition as to moisture to the bins in the farmer's granary.

Our first experiments at Cornell University, when we attempted drying grain in bulk, convinced us of the futility of this method under our conditions. Accordingly, the work in which we are at present engaged is an attempt to dry a relatively thin layer of grain which is moved forward through cross air currents of progressively different temperature and humidities. The central thought is that the temperature and humidity of the air passing through the grain at any particular stage in the process of drying shall be the temperature and humidity that will bring about the most rapid drying. Just what these are we do not now know. Coupled with the heat and moisture control we propose to supply air under pressure, or moved by an exhauster in very generous volume, as our work thus far indicates that this is necessary for rapid drying.

In the accompanying figure is shown the apparatus as it now stands. The grain is tumbled in a small concrete mixer in the presence of steam which quickly heats and humidifies it. It is then dumped into a farm grain elevator and delivered to the top of the grain passage in the drier through which it passes by gravity to the "grain valve" at the bottom. We may later carry on the preliminary heating in a chamber of the grain passage above Chamber 1.

The grain passage in the drier is sided with metal fly screening tacked at either edge to two-by-four uprights and supported at intervals across the face of the netting by boards set with their edges to the netting.

On either face of the grain passage are chambers so arranged that air is forced through the grain at four different points in the length of the passage. Air forced by a blower and heated by a steam coil is forced into Chambers 2 and 4. From Chambers 1 and 3 air is drawn by an exhauster. In the passage that the air must traverse in passing from Chamber 2 to Chamber 1, there is provided a double steam coil for supplementary heating between stages, while the air passing from Chamber 4 to Chamber 3 must pass a single coil heater. Humidity in the air in addition to that resulting from its passage through the drying grain can be provided for any stage by the use of a jet of steam. Boards, "B," have been installed next to each heater in order to avoid the possibility of the air short-circuiting between stages.

Racks for holding inexpensive wet and dry bulb hygrometers are shown in place and provision will be made for sampling the grain in each stage through holes through the cover and the two-by-four post.

It is anticipated that, if the results with the equipment illustrated prove to be satisfactory, a self-contained portable outfit can be readily designed.

A view of the experimental drier described in the accompanying report

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Professor of rural engineering, and head of the department, Cornell University. Charter A.S.A.E.

Some Preliminary Results of Grain Drying Studies[1]

By W. M. Hurst[2]

AN EXPERIMENTAL grain drier of about 3-bushel capacity was set up at Fargo, N. D., during the 1928 harvest season and a series of tests made on wheat, oats, barley, rye and buckwheat. The drier was designed and the tests conducted to secure information regarding heat requirements for drying grain with heated air at different temperatures and air velocities. A total of 64 tests were made but the data have not yet been worked up for all of these tests. This report is preliminary and contains the results of nine tests made on hard red spring wheat.

The drier (see accompanying sectional view) consisted of a box-like structure, about 18x48x72 inches, supported by corner posts and with a hopper at the top. Two opposite sides of the box were open, the other sides being practically airtight. Screen wire frames, two on each side spaced 6 inches apart, were supported in a vertical position across the open sides of the box to hold the grain in layers. These screen-wire compartments, one on each side of the box, held the grain in vertical layers 6 inches thick. The compartments were filled with damp grain from the hopper and the dry grain was removed through openings at the bottom. Heated air was forced into the box from beneath by a Sirocco fan. The only escape for the air under pressure from the fan was through the 6-inch layers of grain. The screen compartments held about 3 bushels and the grain was dried in batches.

[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

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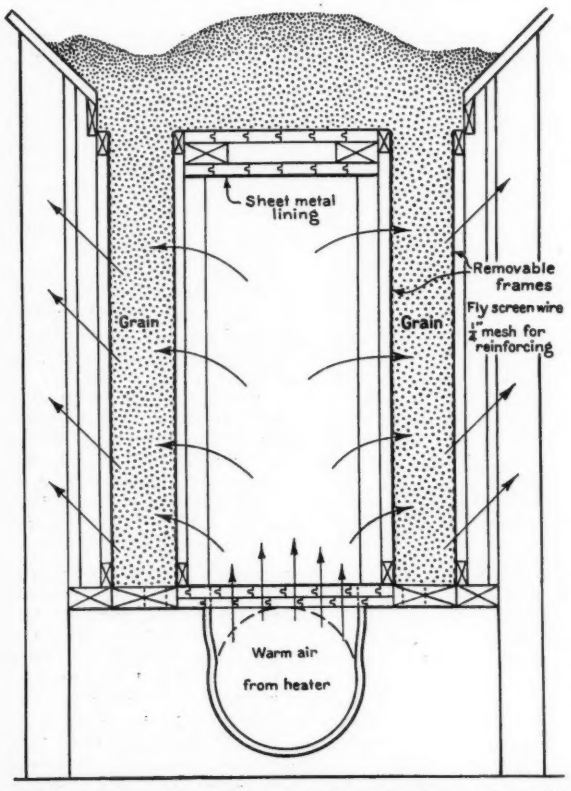

Cross sectional view of the experimental drier used in the U. S. D. A. tests

The drying air was heated by an electric heater made up of forty-eight 300-watt elements enclosed in an insulated heater box. The heating elements were connected to a switchboard by plugs as a means of controlling the temperature of the drying air. The air was forced through 14 feet of 6-inch pipe to the heater box from which it passed into the drier from beneath through an elbow. This long section of 6-inch pipe was used to facilitate accurate air measurements. The No. 1½ Sirocco fan was driven by a 3-hp. constant-speed motor. A damper on the intake side of the fan provided a means to control the quantity of air used for the different tests.

Air measurements were taken with a Pitot tube at the center of the 6-inch pipe at a point about 13 feet from the fan. Watt-hour meters were used in determining the energy utilized in operating the fan and heating air for drying.

At the beginning of each test the drier was filled and a composite grain sample taken for moisture determination, test weight and germination. Subsequent grain samples were taken after the drier had been operating 30 minutes, at the end of one hour, and at the close of the 2-hour test. The test weight and moisture determinations of the grain samples were made by the Grain Division of the Bureau of Agricultural Economics, U. S. Department of Agriculture, and the germination tests were made by the Bureau of Plant Industry.

The wheat for these tests contained less than 1 per cent dockage, between 18 and 19 per cent moisture, and had a test weight of approximately 54.5 pounds per bushel; it germinated about 91 per cent when received from a local elevator. Three tests at different air velocities were made at a temperature of 120 degrees (Fahrenheit), and similar tests at 140 and 160 degrees making a total of nine tests. The atmospheric conditions could not be controlled but only a relatively small variation in the temperature and relative humidity occurred during the tests. The room temperature varied from about 74 to 61 degrees and the relative humidity from 57 to 39 per cent.

The data secured show that the wheat was reduced from 18 to 14 per cent in moisture content in from approximately 40 to 80 minutes depending largely upon the rate at which heat was supplied. The number of B.t.u. supplied by the heater in drying the grain varied from about 14,320 to 10,240 per bushel. The results seemed to show that the quantity of air forced through the grain is significant only in so far as it affects the number of B.t.u. supplied. This would probably hold true only within a limited range of temperatures and air conditions, but it does seem to indicate that it makes little difference whether a large quantity of air is supplied at 120 degrees or a small quantity of 160 degrees, so far as the total number of heat units are concerned. It should not be assumed that 14,000 to 10,000 B.t.u. are always required to dry a bushel of wheat as atmospheric conditions and the quantity of water to be evaporated would need to be considered. However, the heat requirements for drying wheat under the test conditions are equivalent to about 1 pound of coal per bushel of wheat, at 100 per cent efficiency for the heating unit. With a 50 per cent efficiency, this would be equivalent to about 2 pounds of coal per bushel of wheat under the test conditions.

Germination tests show slight variations throughout

each test regardless of the temperature to which the grain was subjected. Two tests show an increase, six a decrease and one no change between the first sample which was taken at the beginning and the last sample which was taken at the end of the 2-hour period. The average percentages of germination of samples taken at corresponding intervals throughout the tests at which the drying air was at a temperature of approximately 120, 140 and 160 degrees, respectively, showed a decrease in germination of approximately 3, 3.8 and 1.3 per cent. The temperature of the grain did not exceed 153 degrees at the center of the 6-inch layers during any of the tests in which the air entered the grain at 160 degrees. A thin layer of grain next to the inner screens reached a higher temperature and this grain was probably affected by the temperature; but the composite samples taken at points about half-way between the outer and inner screen showed that the percentage of germination was affected slightly, if at all, during the drying process within the range of temperature used.

The test weight, or weight per bushel, of the wheat increased as the moisture content decreased, reaching a maximum at a moisture content of 10 to 12 per cent. So far as the data show, the rate at which the grain was dried had no effect on the maximum test weight. The test weights of samples of grain dried under atmospheric conditions varied only slightly from those dried quickly under artificial conditions. The test weight of the wheat used for these tests increased from about 54.5 pounds per bushel at 18 per cent moisture to about 57 pounds per bushel at 14 per cent moisture.

The drier used was too small for farm use, but there seems to be no reason why similar results could not have been secured from a larger unit of the same type. The grain dried uniformly throughout the vertical layers.

Illinois Studies in Drying Grain with Forced Heated Air[1]

By A. L. Young[2]

AMONG the items entering into the cost of drying any material, such as grain, with warm air might be listed: (1) Cost of fuel to heat the air; (2) cost of energy to move the air and the grain (when the latter is moved); (3) interest and depreciation on equipment; (4) shrinkage; and (5) labor. A satisfactory drying method is one that keeps these cost items as low as possible and at the same time gives a dried product of good quality. Usually when rating drying equipment, we emphasize: (1) Its efficiency, and (2) the quality of the dried product. When speaking of efficiency, we refer primarily to the amount of energy required. Sometimes high efficiency must be sacrificed to some extent for the sake of simpler equipment with a low first cost, which can be operated with unskilled labor.

According to Mark's "Mechanical Engineer's Handbook," (page 610) it has been found possible in stationary power plants to evaporate from 14 to 16 pounds of water at 212 degrees (Fahrenheit) with a pound of average fuel oil. In checking over data obtained in drying of grain at the University of Illinois, fuel oil being used as the source of heat, I find that a pound of oil has evaporated from 2.7 to 8.3 pounds of water, the average for fourteen tests being 4.9 pounds. In some of these tests the fan was driven by an electric motor and the kilowatt-hours of energy required was measured. In others a tractor was used and the only data obtained was the cost of fuel and oil to operate the tractor. Although in all cases the mechanical energy required has been only a small fraction of that required in the form of heat, its cost has been no small item. It runs from 24 to 65 per cent of the total energy cost (including heat). In all tests in which a tractor was used to operate the fan, the cost of fuel and lubricating oil for the tractor was greater than the cost of the fuel used to produce heat. This was in part due to the fact that the tractor was not loaded to capacity.

In these tests, the cost of evaporating 1000 pounds of water has varied from $2.57 to $5.68, and the cost of drying per bushel of dried grain has varied from 1.2 to 14.6 cents. In part, these variations are due to: (1) The material being dried; (2) differences in moisture content; (3) amount of the material being dried; and (4) variations in the method and kind of equipment used. In the beginning, the air was heated indirectly in a hot-air furnace equipped with an oil burner; more recently we have been using a portable dryer quite similar to the one previously built at Purdue University. With this dryer the products of combustion from the oil furnace as well as the heated air, pass through the material being dried, and with it the amount of fuel oil required for heating has been reduced considerably, and to a slight extent, perhaps, the amount of mechanical energy required to blow the air.

From the standpoint of efficiency, we are far from satisfied with the equipment we have been using. Presumably the simple, inexpensive and more or less portable equipment needed for the drying of agricultural products on the farm cannot be made to operate efficiently as the large and costly stationary driers being used at elevators. Unless, however, the losses with equipment such as we have been using can be reduced somewhat, we doubt if it can compete with the large commercial dryers.

Another difficulty we have experienced is that of obtaining uniform drying and a good quality of product with a minimum of handling of the product being dried. Perhaps the ideal farm drier would be one that would permit putting the product in the crib or bin in which it is to be more or less permanently stored and drying it, without further handling, at such time thereafter as might be necessary or desirable. The simplest way to do this is to provide a central core in the case of an open-sided crib, or a false porous bottom in the case of a tight-sided bin, and blow the heated air out or up through the material. Blowing heated air in one direction through rather thick layers of stationary material is seldom satisfactory because of: (1) uneven drying: (2) likelihood of material spoiling on the outside where moisture carried out from the inside tends to condense; (3) much unused heat being carried away by the air during the latter stages of drying (low humidity of the air leaving the material). To a large extent these disadvantages are avoided by commercial apparatus that forces the air back and forth through a thin-moving layer of the material being dried.

But perhaps we should not be too much discouraged because our simpler equipment does not in many respects compare favorably with costly commercial apparatus. One Illinois farmer who grows corn on a rather large scale has used his portable dryer, similar in principle to ours, but in actual design more like the one being used at Purdue University, for some 500 hours of drying ear corn (commercial, not seed) and feels that he has done so at a profit in spite of rather high losses that may have occurred. From the standpoint of handling of the materials drying near where they are grown has advantages over drying in a big central plant.

[1] A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

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Studies of Moisture Content and Drying of Combined Grain in Virginia[1]

By D. C. Heitshu[2]

TWO phases of combine harvesting of small grains were given special attention in Virginia during 1928. The first study involved the moisture content of wheat at various periods of the harvest, and the second study was a determination of the feasibility of drying damp combined grain by the use of natural vantilation through flues in the grain bins.

Moisture Content of Wheat. The harvesting season of 1928 was particularly dry, as only 2.2 inches of rain fell during the month of July. The relative humidity was low, as a result of the lack of moisture, and dropped below 50 per cent on thirteen of the nineteen harvesting days. These conditions are not representative of average Virginia conditions, but indicate what may be expected under exceptional seasonal conditions. Eleven consecutive days for combine harvesting of wheat is the maximum that may be expected in Virginia.

The moisture content was determined for standing grain, shocked grain, and windrowed grain. The moisture samples were taken daily at 11:00 a. m. until the grain was ready for the combine. From this time on samples from the standing grain and windrow were taken at 8:00, 9:30; and 11:00 a.m.; 1:30, 4:00, and 7:00 p.m. The shocked grain was sampled at 11:00 a.m. each day. After eleven days, during which time the wheat was suitable for combine harvesting, the wheat began to break over badly and the moisture tests were discontinued.

The most outstanding result of this study is the close relation found between the moisture content of wheat and the relative humidity. While there was not sufficient rainfall to judge accurately, it would seem that rainfall does not affect the moisture content of standing wheat except as the rainfall causes a change in the relative humidity.

A comparison of the accompanying moisture curves of standing wheat and windrowed wheat brings to light the following points:

1. The windrow method of harvesting should allow for a longer harvesting day, since the windrow is drier in the morning than the standing grain.

2. The daily variation of the moisture content of windrowed wheat is less than for standing grain, which means drier wheat in the windrow in the morning, while the standing grain is equally as dry, or even drier, late in the day.

3. The effect of rain upon windrowed wheat is not known, but the indications are that the standing grain absorbs less moisture from rain than windrowed grain, but the windrow seems to dry more rapidly.

4. The test plot was free of weeds, but the windrow method should reduce the threshing troubles resulting from weeds, and keep the moisture of the combined grain lower because of the absence of green weeds in the grain.

Grain Drying by Natural Ventilation. The natural ventilation flues were tried in 6x6x6 foot grain bins, the flues being placed 18 inches on centers, one bin having horizontal flues and the other vertical flues. The flues were constructed of two 1x4 inch pieces held 6 inches apart by 1x1 inch cleats and covered with fly screen.

These bins were filled with wheat cut July 19, 20, 21 and 23. The wheat was dry and in good condition except for the weeds present. The weeds caused the moisture content of the combined grain to be higher than that recorded on the test plot. The bin equipped with horizontal flues was filled first, and on July 24 a composite sample from this bin showed a moisture content of 14.7 per cent. The bin with the vertical flues was filled last, and rain on the night of July 22 with a slight shower the morning of July 23, while the combine was operating, caused the moisture content to be higher in this bin. On July 24 the composite moisture sample indicated 16.25 per cent moisture present in this bin.

No heating or other troubles occurred, and in nine days, August 1, the moisture contents had dropped to 13.15 and 15.45 per cent in the horizontal and vertical flue bins, respectively. There was a slight trace of moisture perceptible in the vertical flue bin. In 15 days, August 7, the moisture contents were 13.25 per cent in the horizontal flue bin, and 15.05 per cent in the vertical flue bin. At this time the wheat seemed cool, dry and sweet in both bins.

The wheat in these bins dried to 13.3 per cent in the horizontal flue bin, and 13.35 per cent in the vertical flue bin in 29 days, this was August 21. September 5 the grain was removed and cleaned in a fanning mill. A slight trace of must was found in the horizontal flue bin, and a trace in the vertical flue bin. At places where the percentage of weeds ran high the wheat was musty, but this trouble, it is believed, can be controlled by removing the weeds a few days after the harvest.

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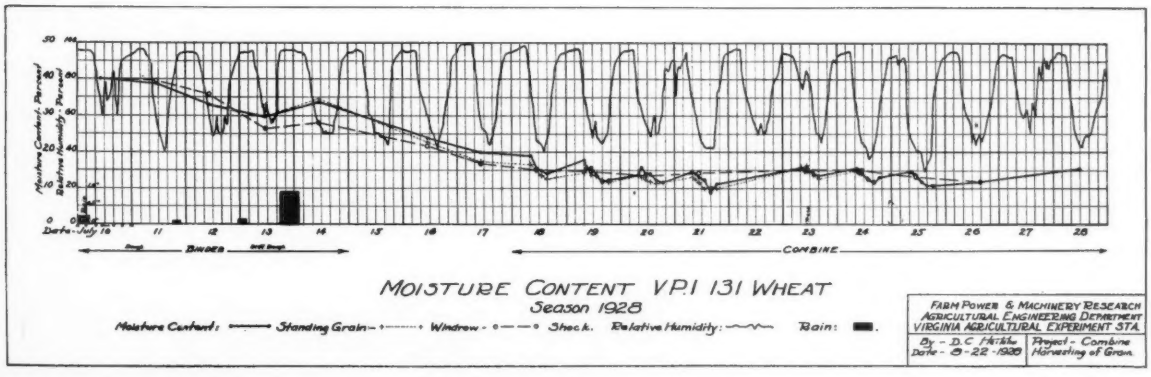
Moisture Content, Percent
Relative Humidity, Percent
Date - July 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Swath
BINDER
Swath
COMBINE
MOISTURE CONTENT VPI 131 WHEAT
Season 1928
Moisture Content: Standing Grain - Windrow - Shock. Relative Humidity: Rain:
FARM POWER & MACHINERY RESEARCH
AGRICULTURAL ENGINEERING DEPARTMENT
VIRGINIA AGRICULTURAL EXPERIMENT STA.
By - D.C. Heitshu
Date - 8-22-1928
Project - Combine Harvesting of Grain.

Considering the results obtained this year it is felt that simple naturally ventilated bins hold great promise for the eastern farmer using the combine.

The Combine. Having used the combine for two years in Virginia, the following features are believed desirable for eastern combining conditions:

1. A flexible or floating header
2. A header draper not less than 36 inches wide
3. An enclosed feeder housing
4. A separator capacity to care for 30-bushel wheat and 36-inch straw at 2.5 miles per hour
5. A machine capable of working on rolling ground
6. A satisfactory straw-handling method.

A sturdy, well-built machine incorporating these features would do much toward solving the eastern farmers' combine problems.

Combining Under Adverse Weather Conditions[1]

By F. C. Fenton[2]

THERE were two major problems in the Kansas harvest this past year. The first was to propel the combine through the wet fields, and the second was in handling the wet wheat after it was harvested.

The combine is no longer an experiment in Kansas. There were about 20,000 in use during the past season, and probably 60 to 75 per cent of the total crop was harvested by these machines. Under normal Kansas conditions the weather is ideal for the operation of the combine, but this year was an exception. One Kansas farmer expressed it fairly well when he said: "I've been farming for thirty years, during which I've spent fifteen years waiting for it to rain, but this summer I've spent months waiting for it to stop raining."

Harvest began during the first week in July, about a week later than usual, due to a wet June. And, as usual, the harvest was started before the wheat was dry enough to keep in storage. With 700 acres of wheat to harvest with one combine, it is hard to wait after the grain appears to be ripe. After a few days of good harvesting weather it began to rain (hail in some localities) and blow. Rainfall varying from 7 to 10 inches fell throughout the wheat belt during the month of July. There were periods of damp foggy weather in between the rains. One weather station reported rain on 15 days of the month.

The big problem was to pull the combine through the fields during those rare intervals when the wheat was dry enough to harvest. The wheel type tractor was at a big disadvantage and often two or three tractors were used on one combine. Horses were called into use to pull through the softest spots. The crawler track-type tractor, of course, performed much better. The experience at the state college experiment station at Hays is typical. There they have a 20-foot combine, and a 30-60 tractor which has been used in the past to pull it and which was helpless in the soft ground. The farm superintendent secured a crawler track-type tractor and made such good time that they finished July 27 harvesting 550 acres, which yielded 35 bushels per acre. The next day after finishing a 5-inch rain came and put an end to the wheat harvest in that section.

Wherever it was possible to move the combine through the fields, a remarkably good job of harvesting was done, considering the condition of the grain. With lodged and tangled grain, the cutter bar had to be run very low, and many kinds of guard attachments or fingers to pick up the wheat were tried. If the wheat could be raised enough to get the cutter bar under it, the combine did the work successfully. After a few weeks of rain, the weeds began to grow up through the lodged wheat and the difficulties of harvesting were increased. There was a great demand for the windrow pick-up attachment at this stage of the harvest. Many more were demanded than could be supplied by the implement companies, which were not prepared for this emergency.

The farmers kept digging away at the wheat harvest until by the middle of August the weeds were so thick and so high that further operations were impossible. Probably 10 per cent of the wheat was never harvested.

In spite of all the difficulties, there was little tendency to criticise the combine, partly because the other methods were also unsuccessful. Of course, the farmers using binders and headers began operations earlier, and when the rains came, apparently had a larger proportion of their crop safely in shock or stack. But the shocked wheat was badly damaged before it could be threshed. Stacked wheat from the header, which has been coming on the market during the past month is so musty and molded that it grades No. 5. The combine seems to have been just as successful as any of the other methods of harvesting, in spite of unusual weather conditions.

Marketing this crop of damp wheat resulted in greater losses to the farmer than the harvesting. In normal years there is little damp wheat and the Kansas farmer is totally unprepared to handle a large crop in this condition. He was afraid to hold it and dumped it on the market as rapidly as possible. The Kansas City market received 24,868 carloads of wheat during the month of July. This was about 36 per cent of the total year's receipts. The market facilities were overwhelmed with wet wheat, much of which had spoiled on the way to market. There is little wonder that the price dropped rapidly. No. 2 wheat sold for $1.60 a bushel at Kansas City on July 1, but the bulk of the wheat marketed during July brought the farmer 85 to 90 cents. The need for farm storage and orderly marketing was never more strongly shown. The loss which was sustained by Kansas farmers due to this unnecessary drop in price would have paid for adequate farm storage facilities.

Very little farm storage is provided in the wheat belt of Kansas. Figures collected in a survey in thirty-five leading wheat-producing counties in 1928 show that there were 30 million bushels in excess of the storage facilities on the farms and in the elevators. The common practice of piling the wheat on the ground until it could be marketed was followed this year, but with frequent rains the wheat was damaged considerably. The storage problem is the outgrowth of the combine and is serious. Unless the wheat can be stored and marketed more slowly, the losses will more than off-set the savings due to lower production costs.

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[2] Professor of agricultural engineering, Kansas State Agricultural College. Mem. A.S.A.E.

The Function of Paint

THE principal function of paint on exterior surfaces, as stated in the distributors' edition of the U. S. Department of Commerce booklet "Seasoning, Handling and Care of Lumber," is stated in the booklet to be the prevention of mechanical erosion by rain, wind and frost, and not, as commonly supposed, for appearance or for preventing moisture absorption by the wood. Paint coating slows down moisture absorption and thus reduces the rapidity of moisture content change, thus also preventing the rapid change in stresses so injurious to the interior structure of lumber, but its principal function is prevention of surface erosion.

Field Problems in Combine Harvesting[1]

By J. Fletcher Goss[2]

MOST of us have come to the conclusion that the combine is here to stay and in a few years practically all of the small grain will be harvested by this method. Still there are some unsolved problems that need our attention. Last year I made the statement that weeds were our biggest problem. They still are although the use of the windrower and pick-up has solved that to some extent. For some farms the saving of the straw is a big problem. Bunchers seem to be only a partial solution. Rainy and damp weather always will be a problem in some seasons and seemingly we have no control of this.

The year 1928 was an exceptionally bad combine year in South Dakota. It was dry in the spring which gave the grain a poor start and the weeds a chance to crowd the grain. Then later rains started more of the grain giving very irregular fields. Most all of the small grain was short and a good deal of it very weedy. These conditions alone are bad enough but Mother Nature didn't think so, and gave us a wet harvest season to contend with also. In spite of the adverse season the number of combines in the state were more than doubled over last year. There are about 500 combines in South Dakota now.

The windrow and pick-up method is very much in favor especially in the eastern portion of the state. Direct combining for most crops is usually satisfactory in the central and western parts of South Dakota. Leo Preston, a good farmer near Castlewood, purchased a combine last year and harvested all of his grain combining direct. This year be bought the pick-up and used it for most of the grain. He told me that the pick-up had solved all of his problems. Last year he had a little trouble with green material giving him some damp grain; this year he had no complaint to make at all.

The hail and wet weather hazards are much less when the windrow and pick-up method of combining is practiced, because the grain is off the field a few days sooner than it would be if they combine direct, and several weeks sooner than if it were bound and shocked. Ordinarily they windrow or swath at the same time they would cut with a binder and then it is ready to pick up and thresh three or four days later depending upon the weather. The weather does not seem to damage the grain in the windrow as much as in the shock. If the straw is very short and it is not possible to make a good windrow on top of the stubble the heads may get down on the ground and spoil. I saw one machine picking up wheat that had been in the windrow two weeks and had had three fairly hard rains on it accompanied by some cloudy weather. The machine was doing a very good job of picking up the grain and it was in very good condition.

HARVESTING SWEET CLOVER

Sweet clover is a crop that has always been a problem when harvested for seed. It ripens irregularly and shatters very easily when ripe making it hard to handle without losing the seed. In binding almost half the seed is lost. It is not practical to combine direct because there are always some green seed and blossoms when the large proportion of the seed is ripe. The windrow and pick-up seems to be the ideal method of harvesting sweet clover. I have visited three different men who has harvested sweet clover by this method. One man had some large bushy clover and some of the windrows were shattered rather badly by a high wind. The wind does not disturb small grain windrows.

H. B. McKibben, a farmer near White, S. D., raises a great deal of sweet clover. This year he purchased a combine and has harvested all of his small grain, about 400 acres, as well as 150 acres of sweet clover, all by the windrow and pick-up method. He also harvested nearly 200 acres of sweet clover for several of his neighbors. He says he gets two to three bushels more per acre than he could by any other method of harvesting. One of his neighbors told him that he got enough extra seed to pay for harvesting.

THE MOISTURE PROBLEM

This year we operated a small combine on the college farm and on other farms near Brookings, and made a special study of the moisture problem. We tried to determine how much the moisture decreased from day to day as the grain was ripening and also the moisture at various hours of the day when the grain is ready to harvest. We harvested two 10-acre fields of oats, 18 acres of barley, 20 acres of wheat and 8 acres of flax.

One field of oats was on the college farm. It was good oats for this year, but like most of the small grain in this section of the state it was rather short, irregular and a little weedy. We cut the first sample July 26. The moisture content was 23.2 per cent. By July 30 the moisture had dropped to 21.2 and on August 1 it was 18.8 per cent. On August 6 and 7, eleven days after the first sample and two weeks after it was ready to cut with a binder, the field was finished. Samples were taken each hour to get the variation during the day. At 8:00 a.m., the grain contained 20.4 per cent because of a heavy dew. At 9:00 a.m., 18.0 per cent; at 10:00 a.m., 16.0 per cent, and at 11:00 a.m. it was in good shape for storing, containing 14.4 per cent. From 12:00 to 7:00 p.m. it remained nearly constant, varying from 11.2 to 13.2 per cent. At 8:00 p.m., which was just at sun down, the moisture jumped up to 14 per cent. The other field of oats was on a farm near Brookings and should never have been combined unless it had been windrowed, as it was badly infested with weeds. The moisture content varied from 16.8 to 22.0 per cent during the day of August 4. The oats were dead ripe and dry, but it was impossible to separate all of the green material from them. These oats were spread out two feet thick in a large bin and none spoiled or heated. If a larger quantity had been stored, it would have spoiled however.

The barley that we harvested was for a man who came in and asked us to come out and try the combine because he could not bind it. The barley was short and a heavy growth of Russian thistles stood nearly as high as the barley. This gave grain that was high in moisture, as would be expected, because of the Russian thistle tips. From 7:00 a.m. to 1:00 p.m. the moisture content dropped from 18.0 to 15.2 per cent. At 2:30 p.m. it was 12.4 per cent, and it stayed so that it would be safe for storing until 6:30 p.m. On this particular field, cut July 31, the grain was in condition for harvesting only between 2:00 and 6:30 p.m.

On August 7 the first sample was harvested in the field of Durum wheat. The moisture content then was 19.6 per cent. On August 9 it was 17.2 per cent, and on August 11 it had dropped to 13.0 per cent. The remainder of the field was harvested August 13. At this time the weeds were much worse than they appeared to be a few days before and the grain had lodged some in places. The moisture content of the grain harvested at 8:00 a.m. was 19.0 per cent. It was 16.6 per cent at 10:00 a.m. From noon until 7:00 p.m. the moisture varied between 13.6 per cent and 15.0 per cent. At no time was the moisture

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[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Assistant professor of agricultural engineering, South Dakota State College. Assoc. Mem. A.S.A.E.

as low as the sample taken two days before. The main reason was that the weeds had become higher, and the grain down in places made it necessary to run more green material through the combine.

We were not successful in harvesting the small field of flax we had intended to get some results on because of the rains at harvest time. The bolls were ripe but the straw stayed green and got even greener. New shoots came out and new blossoms formed after the flax was past the stage where it was ready to cut with a binder. On September 22, three weeks after it was ready to cut with a binder, we combined the eight-acre field but there was too much green material in it. The moisture of the flax harvested during the day varied between 13.0 to 14.8 per cent, which is high for flax. More than one-third of the bolls had fallen off by this time so there was a considerable loss by waiting so long. In a dry year flax can be combined direct satisfactorily and it was by some farmers in South Dakota last year. This year the windrow and pick-up method would have been much more satisfactory.

In conclusion I will state that from what we found this year most grain is not in good condition for combining direct until 11:00 a.m. and not after 7:00 p.m. Where the pick-up is used, longer hours could be put in. We also found that when combined direct it is important to let the grain stand until it is thoroughly ripened but not long enough to let the weeds get up so many of them have to be cut and run through the machine. It is certain that under many conditions windrowing or some other means of taking care of weeds and green material is necessary to supplement combining direct. We hope next year to get more information on windrowing or some other means of taking care of the weeds and green material.

Combine and Grain Drying Experiences[1]

By C. O. Aspenwall[2]

THERE have been a great many interesting things advanced at this meeting, but the story hasn't been half told about the harvester-thresher, or "combine."

This session has dealt mainly with harvesting grains and soybeans with the combine, but as many of you know, it has been used for a great variety of harvesting. We have reports in our office where men have harvested all kinds of grass seeds, such as blue glass, timothy, orchard grass, turnip seed, and we have reports from two men in Texas who have picked their cotton with it. So that it is put to a lot of different kinds of work.

It is like other new machines; the farmer expects too much of it. He puts it to a lot of different uses when it is new, and before he has tried it out and knows the problem from the ground-up. Consequently, he sometimes gets into trouble. But as a general thing he gets along very well because he invented his way of doing a particular job, and he brags about it.

The requirements of this device are many, and there are some things which must be corrected in its development. Mr. MacKenzie says it has a habit of picking up willow roots. No one knows how tough they are until he has put one through a threshing machine. It also has a habit of picking up pieces of chain, rock, old boots, leather or rubber, etc. Something must be provided to stop breakage in this machine as much as possible.

The machine should have an automatic control, connected with a piece of rope or a lever, so the man driving the tractor or operating the machine when he notices foreign material going on to the platform can, by pulling the rope or lever, stop the machine.

Some machines are equipped with volume control, which takes care of large bunches of grain that come in and stop the platform canvas and the traveling of the grain towards the machine. Naturally, if the man driving the tractor sees the platform is going to be stopped, he can slow down the tractor for a while.

The International Harvester Company has done a great deal in trying to solve the grain drying problem. We have spent a great deal of money designing apparatus and carrying on tests and we have not yet solved it, by a long way.

We purchased a regular grain bin such as is used in the Northwest for storing grain. It is a circular bin 12 feet in diameter and 9 feet high. We mounted it and cut a circular hole in it about 8 inches in diameter and ran a pipe from there to a blower.

We ran the blower for several weeks, and tested it first one way and then another. We learned a great deal and, of course, had some peculiar things happen. For instance, by blowing air into the bin for a certain time in the forenoon and in the afternoon, we could reduce the moisture 2 per cent, that is, from 20 to 18 per cent. And when we went back again in the morning, the two per cent moisture taken out the day before would be back in the grain again. We would take out the two per cent of moisture again that day, and the next morning it would be back in again.

We wondered how much air passed up through the center of the pile of grain and how much went up around the sides of the bin. Naturally when you put grain into a bin, wherever the spout is set there will be more sediment and fine particles there than there will be other places. The pile of grain nearest the spout is more dense, and naturally, in those places there is more resistance to the air. Therefore, the air won't pass through the center of the pile as readily as it will around the outer edges.

So at the mouth of the blower we created a smudge of green leaves and wet straw, started the blower and then went over to the grain bin to see where the smoke came up. We were surprised to find that no smoke came up through the center at all, but that it all came up around the edges, and it continued to come up there.

When kernels of grain are pressed up against a flat surface, such as the side of the bin, there is more open space between the grain and the bin side than there is in the center of the bin where the kernels are squeezed together. The air, of course, in our blower test took the path of least resistance and traveled along the bottom of the bin and up around the sides.

This suggestion which I have made to thousands of farmers and local dealers may be the solution of the drying problem: If grain is never piled to exceed five feet deep (four feet is preferable) and common boards planed on both sides are set vertically in the pile about every two or three feet, the grain will have an air circulating surface around those boards. Just as soon as it starts heating at all it creates its own ventilation. And if enough boards are put in, I will guarantee it won't spoil; we have never had a case yet where it did. It is a matter of getting the moisture away from the kernel of grain by its own heat which it creates.

[1] A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2] Associate manager, engineering department, International Harvester Co. Mem. A.S.A.E.

Windrow and Pick-Up Attachments[1]

By I. D. Mayer[2]

DIFFICULTIES encountered in the straight combining of oats in 1927 led to the study of the windrow and pick-up attachments during the 1928 harvest. Straw, broken grain, green weeds and sweet clover necessitated slower cutting and caused trouble by slugging the cylinder and clogging the screens when oats were combined direct. Separation was incomplete and green material in the grain raised its moisture content enough in some cases to cause heating and molding in the bin. Since these difficulties were encountered primarily in oats and because of the wheat failure this year, the studies of the windrow and pick-up attachments in small grains were confined to oats.

Two makes of equipment were used. Windrowing was started two or three days after the grain was ready to cut with the binder and continued periodically until the grain was ready to combine direct. While no great difficulties were encountered in windrowing, it was found that some care must be exercised in order to make a good windrow and to lay it smoothly upon standing stubble. Windrows dropped in bunches or in wheel tracks cannot be picked up cleanly. Best results were obtained where the stubble was left 10 to 14 inches high. Grain in windrows was ready to thresh about the same time as standing grain was ready to combine direct, which was from 5 to 7 days after the first windrows were made. Two clear days in a windrow was sufficient time to dry out the weeds enough so that the grain could be cleaned satisfactorily. Weedy oats combined direct had a moisture content of 13.6 per cent while grain threshed from a windrow cut two days previous, contained 10.8 per cent.

If the windrows are well laid, the grain will withstand unfavorable weather conditions without serious damage. Rain amounting to 0.74 inches in 1½ hours caused no noticeable damage to windrowed oats but standing oats were beaten down quite badly.

Windrow headers used were of the ground-driven type. In soft ground or heavy grain or weeds, there was noticeable slippage. In one field it was necessary to put on extra lugs to obtain sufficient traction. The self-cleaning sickle bar in which the sickle sections protrude past the ends of the guards, did excellent work in down grain, weeds and vines. It was necessary, however, to travel more slowly in standing grain with this bar than with the standard sickle bar. In rank weeds there was a tendency for the material to collect on the platform and to be dropped in bunches rather than in a uniform windrow. This was a handicap when operating the pick-up.

While there was very little shattering while the grain was in the windrow, there was some loss due to the agitation of the grain while picking it up. Most of the grain which was shaken loose during this operation was dropped upon the ground. This loss was sufficient to make the former location of windrows easily visible after the grain had sprouted.

Where the windrows were well made the grain was readily picked up and placed upon the platform canvas, but where the windrows were irregular or bunched operation was not so uniform and the cylinder was slugged occasionally. A governor and throw-out clutch for the platform canvas checked many bunches from slugging the cylinder.

The pick-up operated by a ground drive had the advantage of enabling the operator to regulate the feeding of the combine more uniformly, for stopping the tractor stopped the pick-up and checked the feeding, allowing the machine to clean itself. The power-driven pick-up tended to continue to pull in the windrow after the tractor had stopped. This was most noticeable when approaching a large bunch in a windrow.

When combining direct, the capacity of the cylinder was usually the limiting factor, but when picking up from the windrow, the straw and weeds are drier and if the machine is fed to the cylinder capacity, the separating parts are apt to be overloaded. Threshing losses were as high as 20 per cent when the combine was fed to cylinder capacity from the windrow.

Judging from the experience of the past two years, it appears as if the most satisfactory results with the combine under Indiana conditions will usually be obtained by combining wheat direct and by windrowing oats. Under such conditions, the farmer will frequently be combining wheat about the same time that he will want to windrow oats. In order to make this a practical farm procedure, the application and removal of windrow and pick-up attachments must be simple operations which can be done in a short time

Present indications are that with some minor improvements, windrow and pick-up attachments will enable the combine to satisfactorily harvest weak strawed and weedy grains as they are found under corn belt conditions and they will also increase materially the acreage which a given machine can handle in a season.

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[1]A contribution to the symposium, entitled "New Developments in Combine Harvesting and Grain Drying," presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Assistant agricultural engineer, Purdue University Agricultural Experiment Station. Assoc. Mem. A.S.A.E.

Views showing grain laid in the windrow with the heads near the surface. This gives continuity to the windrow and facilitates the work of the pick-up device

Development of a Hay Drier and Its Use on an Eastern Farm[1]

By J. H. Fulmer[2]

FROM 1904 to 1924, I was engaged as a Ford automobile dealer, having two branches and a large contract, which, of course, meant a large allotment of tractors. In 1917 when the Fordson was being introduced, I, as well as some other dealers throughout the country, conceived the idea that the best way to convince our farmer prospects of the practicability of the tractor was to establish a horseless farm and there prove, by practical demonstration, the advantages of owning a tractor.

In 1920 I purchased what was known as Green Acre Farms, consisting of 235 acres. I then bought surrounding farms until I had a total of 625 acres of good tillable land. This land is a loam, underlain with limestone, slightly rolling and well drained, and has a valuation for farming purposes of about $250 per acre but a much higher valuation on a mineral basis.

I am mentioning the value of the ground that you can better understand that it is a productive soil and better appreciate the difficulty of obtaining a fair return on the capital investment in these times of low prices for farm products. (These farms are in the heart of the cement region, with mills on all sides. We sometimes wonder if the proximity of the mills is a benefit to our lands because of the ash, potash and sulphur thrown off by their stacks. This is a problem which I believe will have to be looked into within a short time by the agricultural engineers in conjunction with chemical engineers who are engaged in agricultural research work.)

During the last eight years we have conducted a horseless farm, raising all the crops grown in the East, such as corn, wheat, oats, barley, alfalfa and potatoes. During the first few years we specialized in growing alfalfa, mowing about 200 acres and shipping the hay to the New York market. The alfalfa venture did not pay, and after receiving a return of $7.68 for a carload of hay, I decided that would be the last car of hay to leave the farm in the form of bales. At that I do not believe the hay was actually worth much more than I received for it, as due to weather conditions on the Atlantic coast line, it is impossible to cure a good quality of hay. The frequent rains, the heavy dew, and the rank growth necessitate considerable handling in order to get the hay reasonably dry, so that by the time it is in storage and baled and reaches the market, it is not only off in color but is chiefly a bundle of sticks. That portion of greatest feeding value, the leaves, is entirely gone. The hay business was set down as unprofitable venture No. 1, and you know that losing money is one of the best of brain stimulants.

It was at about that time I began to reason why it would not be possible to dry hay by artificial means, and from that time until about a year ago, I have given considerable thought to ways and means of accomplishing the artificial drying of forage crops on a scale large enough and with a plant of sufficient capacity to make it profitable.

During the past season we have built and used a hay drying plant which has more than fulfilled our expectations, as we are getting good production at a remarkably low fuel cost. I cannot claim any originality as to the basic idea, because you all know that dehydration of grains, fruits and vegetables has been carried on for ages. Artificial drying of materials used in manufacturing has been carried on for many years; the drying of coal, textiles, painted objects and other materials, is no new practice, and this work has always been done by the application of hot air or steam in the form of indirect heating; that is old. But the drying of materials by the application of direct heat, utilizing all the products of combustion, all the gases, and every B.t.u. in the fuel is comparatively new. This method of drying, as applied to hay and other forage crops has been employed by a number of men with varying degrees of success, and I wish to emphasize right here that a great deal of credit should be given to Arthur J. Mason of Chicago, who built and operated the first successful commercial hay drier. The old saying that necessity is the mother of invention certainly did apply in my case. There was a great necessity in the way of ways and means to reduce my operating costs.

As I have stated to you before, my engaging in farming on a comparatively large scale for our section of the country was as an adjunct to another business, and if the farm did not pay, that was charged up to advertising, but there came a time, when the business would no longer stand for such a large advertising bill, and it was then that I started to design and construct implements which would do more work in a given time with less labor expense—implements which it was impossible to buy at the time, such as a tractor-mounted and operated hay hoist, a motor sprayer for spraying potatoes, a motor fertilizer distributor, a four-row corn planter, a wide-tread tractor for pulling a two-row potato planter, a two-row motor cultivator, a motor weeder, a two-row potato digger and several others, always with the sole idea of lowering my operating costs, as I have never attempted to commercialize these special machines. I have taken my profit in the satisfaction of seeing them work and in lowered operating costs, and while

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1928.

[2]Owner, Green Acre Farms (Pennsylvania)

A view of the completed drier developed by Mr. Fulmer and installed on Green Acre Farms

the farmer's bed has not been one of roses since 1920, we have been able to get by in fairly good shape.

MEETING THE LABOR PROBLEM

One of our greatest problems is that of inefficient and high-priced labor. As we are in a thickly populated section with manufacturing plants all around us, it is necessary that we pay as much or more than the plants do, or we would not be able to obtain any labor at all. This circumstance was one of the greatest factors in inducing me to change my method of farming, together with the fact that we have a great natural alfalfa soil and are close to the consuming market.

With our present system, we are able to cut our regular working force from fifteen to three men, hiring three extra men for about 100 days in the year or during the cutting season. Our system requires six men to operate, two men at the plant, one man in the field and three truck drivers. The operation of the drying plant requires a fireman and an operator who cares for an automatic baler, from which the bales are conveyed to storage by automatic conveyors. The grass is fed into the oven by a series of automatic conveyors, taking it from a pit into which it is dumped by the field trucks. The field man operates a Farm-All tractor with mower attachment, which also pulls a side-delivery rake, this one man being able to perform the two operations of mowing and windrowing at one time. The grass is loaded by cylinder loaders which are pulled by the trucks. The loaders are equipped with a special attachment which spreads the grass over the load, and this arrangement can be controlled by the driver. I believe that it may be necessary to mount a small engine on the loader to operate the loader mechanism; this will relieve the truck of practically all of the draft and may be necessary when the grass is wet.

THE DRYING PLANT

As to the drying plant itself, I will undertake to give a brief description of its construction. Starting at the furnace end, we have a furnace consisting of six fireboxes set parallel. These boxes are 3 feet wide and 5 feet deep, giving a grate area of 15 square feet each, or a total grate area of 90 square feet. These fireboxes are of conventional construction and are fitted with grates of special design to burn buckwheat coal. The front is fitted with a special design cast iron frame which carries the feed and ash pit doors. The sides and back are of firebrick, with a special firewall in the back. The top of the firebox, which is 30 inches from the grate, is covered with a series of cast iron plates similar to the lids on a cook stove. The roof, which is of monolithic concrete is 2 feet above these plates. The space between the plates and the roof is fitted with a swinging door or damper hinged at the top. These doors act as an automatic regulator, controlling the inlet of fresh air which will be in direct proportion to the speed of the fan. This fresh air rushing over the plates carries with it the heat which is radiated from the firebox and through the plates. The gases of combustion pass over the firewall in the rear of the firebox and mingle with the fresh air taken in over the top of the cast iron plates. Here they enter the mixing room, located between the furnace and the fan. The construction of this furnace is such that it is possible to lay the hand comfortably on any of the outside walls when the furnace is in full operation, proving that the heat loss has been reduced to a minimum. The mixing room is intersected with a fire screen. The fan is an 8-foot Sirroco fan with a capacity of 78,000 cubic feet per minute at 290 r.p.m. and requires 60 hp. for maximum production. We however, have never speeded this fan over 160 r.p.m., using 30 hp.. Leading away from the fan, which is a bottom horizontal discharge, is an underground air duct, 3 feet deep and 9 feet wide, which runs 30 feet to the oven and continues nearly the entire length of the oven which is 186 feet long. Imagine a building 186 feet long, 9 feet wide and 6 feet high, with concrete floor and roof, and you have a mental picture of the oven. As stated before the hot air duct runs underneath this oven.

The oven is divided into six compartments, each identically alike, or it is a continuation of six ovens. Through the entire length of this oven runs an endless conveyor 9 feet wide. The divisions for the several compartments are made of metal. The top sections are hinged at the top, and ride on the ribbon of grass passing through. The center partition is stationary, and the bottom partition is hinged at the bottom and is held in place by springs. At the furnace end and at the bottom of each compartment is an opening from the hot air duct, 18 inches by 9 feet controlled by a damper. At the other end of the compartment and in the roof is an opening 2 feet by 9 feet also controlled by a damper. The travel of the hot air is from the hot air duct into the bottom of the compartment, through the ribbon of green grass and out the ventilator at the other end. This is repeated six times during the travel of the ribbon which is about 10 inches thick and the width of the oven. The rate of travel is about 7 feet per minute and the time of travel from start to finish is about 27½ minutes. The green material enters the oven at the furnace end and the temperature carried is from 275 to 300 degrees. This temperature can be very easily regulated at the furnace.

As stated before, this plant has more than come up to our expectations. The capacity is about three tons of dry material per hour and the fuel consumption about 600 pounds of coal per ton of dry material. The product, because of the short time required to cure is wonderful; there being no chance for fermentation, no protein can be released in the process. There is no condensation at any point in the oven, and the only element taken from the product is the water. The color remains green and all weed seeds are sterilized.

The plant requires 65 hp. to operate, divided as follows: Fan, 40 hp.; ribbon machine, 10 hp.; conveyor, 7½ hp., and baler, 7½ hp. This power can be either electric, fuel oil or gasoline.

The cost of building the plant is about $15,000. This, of course, will vary in different localities as to the fuel and power available. The cost of the field equipment will vary as to the kind of trucks used but should not be more than $4,000.

The furnace with slight modifications could be adapted to different fuels and the materials used for the furnace and oven might be different; however, it must be borne in mind that changes made without regard to the construction of the plant as a whole, might result in heat losses which would nullify the basic principle of success of this plant. The plant in part and as a whole is covered by applications for letters patent.

OTHER POSSIBLE USES

I can see no reason why a drier of this type could not be used successfully in drying grain, such as combined wheat, oats, barley or corn on the ear for seed purposes. Had I had my drier working one year ago, I believe that I could have saved at least $5,000 on a corn crop of 165 acres. Due to a late spring, this corn was planted later than usual, but through the growing season gave promise of at least an 80-bushel yield. Our first killing frost came two weeks earlier than usual and then it rained continuously for two weeks. The result was about fifty per cent soft corn with resultant crib mold and a discounted selling price on what was left. I believe that this same construction could be used to good advantage for such purposes, by simply putting a fine mesh screen on the conveyor. For seed purposes it would be necessary to reduce the temperature to not over 120 degrees and speed down the conveyor. So that you can readily see there are a number of different uses that a drier of this kind can be put to, and I believe that within the next few years, drying plants will be quite common on our large farms.

It has been shown by analysis that the total food value in forage plants is greatest at some time before the plant starts to produce seed. Delay in harvesting after that time involves waste of land, labor and capital.

Discussion

QUESTION: What do you consider as the cost per ton of this drying process for, say alfalfa?

MR. FULMER: Anywhere from $3.50 to $5.00. That will depend upon the growth and greenness of the material, also the cost of fuel and power.

QUESTION: How much would coal cost in your locality?

MR. FULMER: $5.00 per ton.

QUESTION: Does that include depreciation charges?

MR. FULMER: Yes.

QUESTION: Do you force the heated air through or draw it through?

MR. FULMER: We force it through the furnace and draw it through the pit.

H. W. JEFFERS[1]: The question of dehydration is a very interesting one from an economic standpoint. We have in this country at least a half dozen concerns that are working on it, each in a little different way. I was in Europe this past summer and spent considerable time seeing what they were doing; in fact, a French concern about 25 miles from Paris put on a demonstration for us. There is a Swedish concern, a German concern, a French concern, and at least two concerns in England, one of them being the Institute of Agricultural Engineering at the University of Oxford, which are working on this problem.

GREATER EFFICIENCY NEEDED IN DRIERS

This development is bound to come and we must take the matter seriously. Someone is going to hit upon an economical method of drying. We have operated one of the Mason driers for the last two seasons, putting through a thousand tons of dried alfalfa this year. But we must get greater efficiency in these driers. I think Mr. Fulmer has made a forward step in the plant he is working on. The product is very much superior to any naturally cured product. I don't know how profitable it would be in such conditions as you have in the arid west, but it has proved to be very satisfactory in our section.

We purchase something like 3,000 tons of alfalfa in the various sections of the West. We always send a man every year to go around and pick out the choicest alfalfa we can buy. Rutgers University, and Columbia University under Dr. Sherman, have made preliminary tests on the quality of the dehydrated products as compared with the very choicest western product, and in every case it shows that the western product is lower in quality. As soon as the plant is cut green, the quicker that plant is dried and preserved, the less loss you have. So from the results of the scientific investigation that is being made on the product, it certainly behooves us to keep pretty close tab on the work going on in dehydration.

There is another problem I heard you discussing—I came in late—about the wheat growers and the corn growers, and I am wondering why we don't grow more alfalfa. I know the people in the East are very, very short of their alfalfa demands this year. I know of one concern here in the Middle West, the American Milling Company, that would like to buy 1,000 tons today. It can't be had. The only reason we have taken care of our alfalfa requirements for the coming year is because we got out early and contracted for our supplies before everybody woke up and found they were going to be short. So I think you should raise more alfalfa.

THE DEHYDRATOR AN ECONOMIC PROPOSITION

The dehydrator is an economic proposition, and I believe it is going to be a very important factor in the future. Dr. Woods, of the agricultural college of Cambridge University, has been working on the dehydration of grasses and putting them into cake form. The cakes analyze 25 per cent protein. We have taken rye, wheat, oats, barley, sweet clover, soybeans, and cow peas, and all the forage plants which we think will grow in our section and put them through the dehydrator. We have made an analysis of these plants and find the protein and mineral matter in the young plants is very high. When the plant begins to send up its stock for seeding, then it begins to change right away.

So instead of feeding the grains to the livestock, which contains only a small percentage of the nutrients of the plant, when we begin handling the plant as a whole and cut and harvest it at the time of the year when it is highest in nutrients, and feed less grain, it is going to be a big economic factor in our livestock operations. And with all these different concerns working on systems of dehydration, I think we can look forward to much greater efficiency.

[1]President, Walker-Gordon Co.

Application of Engineering to Dairy Production[1]

By H. B. Walker[2]

ENGINEERING in dairying, as in the whole of agriculture, is relatively new. Such engineering applications now in use are the outcome of economic trends in agricultural production. These trends for the most part are the result of a national industrial progress, characterized by the extensive use of labor-saving machines, shorter hours for workers, and increased wages.

Dairy production has always been an important phase of agriculture because of the importance of dairy products in the human diet. The nature of the business in the United States, however, has changed materially within the past century due to national industrial trends. One hundred years ago approximately nine out of ten workers were engaged in agricultural pursuits. Then the farm dairy products constituted a source of home food supply with such surpluses as were available sold to a relatively small number of urban dependents. In those days dairying was not a major farm enterprise, but almost exclusively a side line, with the labor costs of production charged to general farm chore work.

The rapid growth of our urban population within the past 100 years has changed dairy production to a major agricultural enterprise, calling for the most scientific management upon the part of the owner. Population trends have been to our urban districts. Now less than thirty per cent of our people depend directly upon agricultural production for a living, while within our towns and cities the remaining population dwells and is dependent largely upon the rural areas for its source of dairy products. Moreover, the tendency in the food consumption of the nation is toward a greater per capita use of dairy products[3].

The labor situation in dairy production has likewise passed through a great transition period. Industrial development in our cities has been brought about by increasing the output of the worker through the utilization of labor-saving machines. In this the laborer has profited by shorter hours of work and better pay. These conditions have affected the labor market for agriculture. No longer can farm labor be expected to work extra hours to perform the family chore of milking cows. Such work is now classed as a major farm operation, requiring the same recognition of hours of labor as observed in other industries. Moreover, the producer of dairy products is faced with an increase of wage scales relatively higher than the relative wholesale prices he receives for his dairy products[4].

Another factor which is destined to exert a great influence upon the methods of dairy production is the more rigid public regulations in the production and processing of dairy products. Consumers being in the majority and dependent upon dairy products as a major food, are not likely to become more liberal in quality requirements but rather we may expect even more rigid regulations in the future. These regulations require for the most part a more sanitary and skillful handling of the products, and such requirements can normally be most efficiently met under conditions of large-scale production.

TREND TOWARD LARGER AND BETTER HERDS

The number of dairy cows per farm in the United States averages a little less than four, while the average for the more important dairy states, such as Vermont, Wisconsin, New York, Minnesota and California, is more than twice the average of all the states. If we assume that dairying in these states has been developed economically, undoubtedly the conclusion is justified that the future tendency in dairy production will be toward larger and better herds, handled by better trained and more skillful managers.

The manager of a profitable dairy production business is faced with the problem of quality production at low cost. In this his business is not unlike any other industry. This requires, in addition to a suitable herd, a modern, sanitary producing plant, equipped with dependable labor-saving equipment. In meeting this problem engineering has contributed much and will continue to contribute to a solution of the industrial phases of the business. Good management is, of course, essential, but in any project requiring skillful management and involving considerable hand labor engineering applications have an appeal.

The proper housing of the dairy herd offers many engineering problems. Fortunately certain parts of the dairy barn are pretty well standardized. This is particularly true of the floor space of cow barns. The dimensions of stalls, mangers, curbs, gutters, feed and litter alleys are practically standardized and the advent of concrete has

[1]An address before a meeting arranged by the Committee on Dairy Equipment, under the sponsorship of the Pacific Coast Section of the American Society of Agricultural Engineers, in connection with the Pacific Slope Dairy Show, at Oakland, Calif., November, 1928.

[2]Head, division of agricultural engineering, University of California. Mem. A.S.A.E.

[3]Economic Aspects of the Dairy Industry, by Edwin C. Voorhies, Pg. 67, Bul. 437, U. of C.; Col. of Agri., Agri. Exp. Sta., Oct. 1927.

[4]Bul. 437, Pg. 119.

A sanitary farm dairy house, as required by regulations in many states. It provides, for the farm handling of milk, a place isolated from the dust and dirt inevitably Associated with many other farm operations.

made available a material quite well suited to meet the requirements of a sanitary floor system. These requirements for a floor system to care for two rows of stock can normally be met in structures 34 to 36 feet wide.

The facing of animals is a factor in economic design. Data developed by Cornell University[5] indicate that a saving of 5 minutes per day per cow is secured by facing the cows "out," as compared to barns where the cows face "in." In a 60-cow barn this would mean a saving of 5 hours per day, or a daily labor cost of $1.50 to $2.00 per day. The saving, however, is based upon the present plan of milking cows at the stanchions and caring for them in the usual way.

Within recent years some effort has been made to reduce investment costs in equipment and to improve sanitation by the practice of establishing mechanical milking units in milking apartments at some predetermined point in the barn, thereby overcoming the necessity of milking cows in the stanchion where feeding and housing are provided. This practice, if established, offers attractive possibilities in helping to solve the general problem of quality production at low cost.

The profitable dairy barn must be a clean barn. An important factor in producing quality milk under sanitary conditions is an abundant supply of pure, wholesome water. Studies conducted by the Kansas Agricultural Experiment Station[6] show that 25 to 30 gallons of water per cow per day are required for the cow, the cooling of her milk (where water is used for cooling), and for the cleaning of her housing quarters. The development of a satisfactory water system with accessories for the convenient consumption and use of this water is an important engineering problem. A good water system will not only help production and improve sanitation, but it can be an effective adjunct in reducing man-hours of labor in the care of livestock.

The milking machine is established as a labor-saving device in dairy production. It still meets with some opposition by dairy managers, but its successful use for many years by producers throughout the country has established its value as a labor saver. The large number of types sold, however, indicates the lack of standard practice in this equipment. A review of data[7] on the operation of mechanical milkers reveals mostly data relating to energy consumption. These data, however, cover only one factor in operation which in itself is relatively small. The factors of proper operating vacuums, effect on animal and ease of cleaning are more important to the producer of milk. Unfortunately data on these points are not so abundant and more are needed before the milking machine becomes entirely free from the criticism of dairy producers. In the final solution of such problems the combined knowledge of the engineer and the dairy scientist is needed.

STERILIZATION NECESSARY

The engineering problems connected with the handling and processing of milk at the place of production are perhaps more interesting. The sterilization of milk-handling equipment is a necessity for high-grade production. The use of steam sterilizers is more or less standard practice, but these require careful operation for satisfactory service. The moisture accompanying the usual steaming methods presents one of the most troublesome factors. Some practical method to meet this problem is desirable. Studies now being made by Farrall and Regan at the California Agricultural Experiment Station with humidified dry air sterilizer offer considerable promise in the development of an effective sterilizer, that will operate at lower cost and leave the cans and utensils in a dry condition. Sterilizing apparatus should be practically automatic in operation since the dairy producer has little time or inclination to "tinker" with complicated equipment. More engineering study and thought are needed to develop such equipment to meet the specific requirements of the producer.

IMMEDIATE COOLING

The cooling of milk immediately following production is a consumer requirement placed upon the producers of market milk. Many methods are in use but the tendency is unmistakably toward the utilization of mechanical cooling units. Here, again, we have an engineering problem of great magnitude and importance. The producer who desires to use such equipment is faced with an investment problem ranging from a few hundred dollars upward to several thousand, or even more. He cannot afford to invest in a machine which does not meet his requirements for satisfactory and economical operation. Standardized methods of rating machines would be helpful in meeting the user's difficulties. Engineering science has contributed greatly to advancement in this field, but the products of his skill and scientific training will not meet with uniform success until more data are developed to determine the requirements of the producer. The program of this morning indicates that engineers are making a determined effort in this direction.

The engineering applications in dairy production are destined to be important factors. The few specific applications outlined are but typical of many others, as, for example, the processing of feeds for dairy cows, mechanical ventilation, lighting, can and bottle washing, fly control, cream separation, etc. As yet but few technically trained men are devoting their time and thought to the specific problems of the producer. The manufacturing field has been heretofore, and is yet, the more attractive from an engineering standpoint. As the demand for quality milk increases, however, the necessity for engineering appliances will become more urgent and apparent. Intensive studies are needed now to point the way for future development.

CONCLUSIONS

In conclusion the following points are submitted to summarize the need and importance of engineering applications to dairy production.

1. The industrial competition of the nation brought about by the extensive use of labor-saving machines, with attendant shorter hours of labor and increased wages, has developed the need of engineering applications in dairy production.

2. The increased demand for dairy products of high quality has a tendency to increase the size of producing units, thus contributing to the more successful use of engineering methods and appliances.

3. The labor situation in competing fields, as well as the general living standards of the individual producer, requires the adoption of methods of production which eliminate the number of daily routine hours of labor.

4. More stringent public regulations, fixed for the most part by the consumer, tend to increase the need of engineering methods in production.

5. The need of well-planned dairy barns, built of relatively permanent materials and equipped with labor-saving devices develops an engineering problem of growing importance.

6. Engineering applied to dairy production will open up new opportunities in management which in turn involve more and better engineering.

7. Dairy appliances, such as milking machines, sterilizers and refrigerators, will become more and more important in dairy production; but progress in these fields depends upon an engineering analysis approached largely from the standpoint of the producer's problems.

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[5] "Labor Economy in Dairy Management," by I. F Hall, pg. 247, AGRICULTURAL ENGINEERING, August 1928.

[6] "The Use of Electrical Energy for Farm Water Supply," by H. B. Walker. Paper presented before Middle West Division, N.E.L.A., St. Louis, May 1928.

[7] "Electricity on the Farm and in Rural Communities," C.R.E.A. Bulletin, Vol. IV, No. 1, January 1928.

Dairy Equipment Problems and Some Recent Developments[1]

By A. J. Cowell[2]

THE humble milk can occupies an important place when it comes to supplying high-grade milk and cream for the market. All manufacturers of dairy products experience the need of a milk can which is of the most sanitary construction, durable, and also a good advertisement for the owner. This requires that the can stay clean and bright on the outside as well as within. Can construction is undergoing change at the present time, the tendency being towards the welded can, that is, a welded cylinder and breast, possibly fitted with a type of bottom that is removable and which will allow for the dissembling of the can so that it may be retinned and reassembled without wrecking some part of the can.

This subject of cans immediately brings up the subject of can washers. There are a multitude of such washers on the market today. Close study of the can washing problem brings to light the need of thorough washing and drying of cans. A suggested series of steps to accomplish this is as follows:

1. Steam soak by the use of low pressure wet steam, which will soften and rinse out all solid matter and fats, preparing the can for the solution wash.

2. Pass cans from steam soaking to a point where they are subjected to a thorough solution wash by means of a rising deflector jet, the construction of which permits direct pump pressure to be applied to all surface parts of the can.

2. Rinse with semi-fresh water applied with a rising jet.

4. Rinse and sterilize with a rinse and sterilizer jet.

5. Dry with hot air; this operation lasts for a period of 60 seconds.

6. Use a cold air displacement jet for displacing the warm moist air in the can with air of atmospheric temperature. This operation, we believe, will overcome the difficulty of cans sweating, as they do when covered, although they appear absolutely dry as they come from the washer.

Care should be taken by the operator to avoid the quick passing of cans through the washer, which defeats the end desired. It is safest to have the washer mechanically controlled as to the time the can remains in the machine. Can washers should be operated in accordance with directions if the best results are to be obtained.

Methods of handling cream for butter making seem fairly well standardized at present and it seems that more thought has been expended in recent years toward the development of equipment to handle market milk and toward the manufacture of ice cream.

The tendency in milk pasteurizing equipment is toward the heating of milk with a low-temperature medium, so as to have only a slight difference in the temperature of the heating medium and the final pasteurizing temperature desired.

Automatic temperature control, both for the heating medium and the pasteurized milk, is recommended. Various methods of pasteurization are used with success, but generally in accordance with the above plan. This allows the dealer to market a product which is efficiently pasteurized, but still retains the natural flavor of milk.

Pasteurizer holding equipment is varied and of many designs, but the demand seems to be for a continuous but positive system, so as to insure a positive holding period of at least 30 minutes.

Following out this same line of thought, there is a general agitation for the use of some form of hooded cap, and legislation on the subject may not be far distant. More than one dealer has been heard to remark that the real need is for a machine that will both fill, cap and apply the hooded cap with one operation. If there are some among you who have in mind a cap that may be so applied, I suggest that it be followed up and developed quickly.

There seem to be many new ideas as to the proper methods of manufacturing ice cream. One is that equipment must be available which will allow for the freezing of ice cream without the use of brine. Such equipment is on the market. It conserves floor space and represents a saving in efficiency in transferring heat by the compressor. Equipment for holding mix and cooling it by artificial refrigeration was exhibited at the National Dairy Industry Exposition.

Control of yield is another angle of ice cream production which is being carefully studied today. A strong effort is being made to make it compulsory to sell ice cream by weight. This means that yield must be uniform from each batch of freeze, as well as from the entire run. It may be that an efficient type of continuous ice cream freezer may be developed which will automatically control yield.

Water conditions at many plants are such that it is difficult to obtain soft water, and alkali in the water supply causes difficulties througout the entire plant, particularly to the efficient operation of the boiler, the can washer and the pasteurizer. The lines cake with alkali and this results in decreased efficiency.

Tinned copper has been the metal most generally used in the construction of dairy machinery for years past. Tinned copper will, however, discolor under certain conditions, and it is impossible to remove the discoloration, without removing the tin from the copper. To overcome this trouble nickel and monel metal have both been tried with considerable success. Stainless steel is now being used experimentally for vat lining in both cheese vats and pasteurizing equipment. This material has shown many advantages, although it is not easy to use in construction work. Neither has it been available in seamless tubing until recently. That difficulty is now overcome and we will soon be able to supply equipment in which tubing is used made from stainless steel.

SUMMARY

Some matters which deserve further thought are: (1) Milk can construction; (2) milk and ice cream washer problems; (3) the possibility of improving bottle caps; (4) ice cream freezers, particularly continuous machines which will allow for the control of the frozen product; (5) the use of ammonia in place of brine as a direct cooling medium; (6) water softening equipment; and (7) metals suitable for milk-handling apparatus.

Dairy equipment manufacturers are anxious to work with the dairy industry. They invite its problems and constructive criticism.

Problems we have in numbers, and to those of us who are developing new ideas there are difficulties to be surmounted, and we cannot hope to reach perfection soon. Nevertheless the work is most interesting and progress certainly has been made during the last few years.

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[1]An address before a meeting sponsored by the Committee on Dairy Equipment of the American Society of Agricultural Engineers held during the Pacific Slope Dairy Show, at Oakland, Calif., November, 1927.

[2]Engineer, Creamery Package Company.

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Investigations of Air Cleaners for Motor Plows and Traction Machinery [trans. title], R. Dull and A. Gorsler (Technik Landwirtschaft (Berlin) 8 (1927, No. 11, pp. 244-252, figs. 22).—Tests of different types of air cleaners for internal-combustion engines used in traction machinery are reported and discussed. In general the majority of the air cleaners tested which are in common use were found to be fairly satisfactory. For the special service conditions imposed on motor plows and farm tractors, it was found that the oil moistened cleaner with centrifugal action gave the best results.

Safeguarding of Machinery and Other Dangerous Plants Used on Farms ([Gt. Brit.] Ministry of Agriculture and Fisheries (London) Miscellaneous Publications 59 (1927), pp. 34, figs. 26).—This is an illustrated pamphlet which indicates the nature of the risks associated with farm machinery, and affords some guidance concerning the precautions necessary to secure proper standards of safety in connection with its working. In addition, it deals briefly from the same standpoint with other classes of machinery sometimes found installed on farms, such as steam boilers, electrical apparatus, and the like.

Protective Metallic Coatings, H. S. Rawdon (New York: Chemistry Catalog Co., 1928, pp. 277, figs. 69).—This book is one of the American Chemical Society Monograph Series and deals with the subject of metallic coatings to prevent corrosion and deterioration of metals. It contains chapters on coating methods depending on the alloying of coating and base; electroplating; metal spraying and sprayed metal coatings; chemical treatment of metallic surfaces; zinc coating by the hot dipping or galvanizing process; zinc coating by cementation, electroplating and other methods—comparison of coatings made by various methods; tin coatings; coatings of copper nickel, chromium and cobalt; coatings of lead, cadmium and aluminum; gold and silver coatings; miscellaneous finishes; and methods of testing metallic coatings. A bibliography is included.

Blowing Stackers for Hay and Straw (trans. title), Dencker (Technik Landwirtschaft (Berlin) 8 (1927), Nos. 9, pp. 197-202, figs. 9; 10, pp. 229-232, figs. 8).—A fundamental study of the principles of operation of blowing stackers for the handling of hay and straw is presented, bringing out especially the influence of the diameter and length of the blow pipe on the efficiency. It was found that the efficiency of blowers ran around 60 per cent. The coefficient of friction was found to be about 0.01. Under these conditions the air velocity was 20 meters per second. The best relative proportions of air and hay were 1 kg. of hay to 3 cubic meters of air.

Stream Flow in General Terms, M. D. Casler (American Society of Civil Engineers (New York, N. Y.) Proceeding, 54 (1928), No. 1, pt. 1, pp. 97-122, figs. 9).—The purpose of this paper is to present a workable general method for the analysis of stream flow in irrigation channels in which the invert slope and the channel cross section are not constant. Demonstrations of the applicability of the method to wires, orifices, and siphons are appended.

Is the Vibrating Shaker as Efficient as the Shovel Shaker? [trans. title] Vormfelde and Knolle (Technik Landwirtschaft (Berlin), 9 (1928), No. 2, pp. 28-39, figs. 25).—Studies of the comparative efficiencies of vibrating and shovel shakers in threshing machines are reported. The results indicate that vibrating shakers give about the same results as shovel shakers. The vibrating shaker, however, presents the advantage that it simplifies the threshing machine, decreases the price, increases safety in operation and reduces the power and labor requirement.

Gray Cast Iron and Black Cast Iron for Harvesting Machinery [trans. title], H. Jungbluth (Technik Landwirtschaft (Berlin), 9 (1928), No. 3, pp. 54-62, figs. 22).—Data are presented on the relative merits of gray and black cast iron, plain and heat treated, for use in the moving parts of harvesting machinery.

Orchard Spraying and Spray Equipment, W. S. Hough (Virginia Station (Blacksburg, Va.) Bulletin 260 (1928), pp. 12, figs. 4).—Practical information on orchard spraying and on the selection, operation, and use of spraying equipment is presented. Special attention is devoted to nozzles and nozzle arrangement.

Agricultural Engineering Studies at the California Station) (California Station, Berkeley, Report 1927, pp. 37-40).—A study of three types of continuous can washers, by A. W. Farrall, to determine the consumption of steam, water, and electricity, together with the bacterial reduction efficiency and cleanness of washing, showed that the use of superheated steam for sterilizing dairy equipment greatly improved the bacterial reduction in cans and made possible efficient moisture elimination. Investigatons of the time and temperature characteristics of oil and electrically heated steam type dairy sterilizers showed that a satisfactory bacterial reduction was obtained in most cases by holding utensils above 170 deg. F. for 20 min. and in all cases by holding them above 210 deg. F. for 20 min. An investigation of an electrically heated hot air sterilizer showed satisfactory bacterial reduction with 10-gal. milk cans held at 230 deg. F. for 30 min. or longer.

An investigation of fourteen types of coating materials for metallic surfaces under conditions found in creameries showed that practically all of the greases, oils, and paints gave good protection for one year, but that light bodied shellac and lacquers failed in less time.

A. H. Hoffman reported that a continuation of studies of dust encountered by carburetors showed that when the carburetor inlet opening faced forward 3.5 times as much dust was taken in as when it faced toward the rear.

In tests of orchard heaters Hoffman found that, even in the cases of heaters that smoked the most, the heat lost in the carbon of the smoke was less than 0.1 per cent of the heat in the fuel consumed in the same time. Also, no appreciable heat was lost in carbon monoxide, and it was concluded that the fuel-to-heat conversion efficiency of all of the heaters tested was practically 100 per cent.

In a study of electrically heated brooders, Moses found the temperature under a brooder heated with glowing coils to be due to radiation from the coils and to convection currents from the floor. Temperature readings revealed that the surface temperature of the wire, the location of the coils, the type of reflector, and the height of the brooder above the floor are all important factors in brooder design.

E. J. Stirniman reported that clogging of the grain drill feed with excess chemical and brush hairs from grain treated with copper carbonate increases the draft of drills and decreases the feeding rate. The amount of free excess material varied with the amount of copper carbonate used per bushel and the length of time of mix from 0.17 gm. for 0.5 oz. copper carbonate treatment per bu. for a 2-min. mix to 0.91 gm. for a 2-oz. treatment for a 10 min. mix.

Stirniman also reported a 95 per cent control of foxtail with a 14-ft. atomizing type of hooded burner when from 40 to 45 gal. of low grade oil per acre were sprayed at pressures varying from 300 to 500 lbs. This also gave a good control of aphids if applied at a certain stage of their development.

Burning with a barrel type stove after the tree had been removed and the stump split by blasting was found by Stirniman to be considerably lower in cost than clearing by pulling or blasting. Burning was not successful on green or wet stumps. The temperature in the barrel stove were found to range from 320 to 980 deg. F. while burning oak stumps ranging from 12 to 18 in. in diameter under a 30-in. diameter steel barrel.

Straw Lofts for Poultry Houses (Wyoming Station (Laramie) Report 1927, pp. 140.—A continuation of experiments on the insulation of poultry houses by the use of straw lofts showed that the houses with the straw loft was from 5 to 10 deg. F. warmer in the early morning and from 10 to 20 deg. F. cooler in midday than the house without the straw loft. During a cold snap, when the temperature went down to — 30 deg. F., the lowest temperature in the house with the straw loft was 4 deg. F. None of the hens in the straw loft house had frozen combs. In the uninsulated house the temperature reached—4 deg. F., and all of the chickens were frost bitten. The eggs from the house with the straw loft had the highest hatchability.

Coefficients of Heat Transfer as Measured Under Natural Weather Conditions, F. C. Houghten and C. G. F. Zobel (Journal American Society of Heating and Ventilating Engineers, (New York), 34 (1928), No. 5, pp. 403-420, figs. 18).—Studies are reported from which data are presented giving the various coefficients of heat transfer found, and the conditions for which they apply, for 44 sections of building constructions of 19 different types.

The conductances found by measurement for three walls containing hollow tile are higher than the coefficients computed

from accepted values for conductivity, indicating that such accepted values do not apply to the tile tested. The coefficients found measurement for concrete are higher than those usually accepted. This is considered due to the fact that the sample tested had not aged sufficiently.

Some aspects are brought out of heat loss for small wall sections between heavy partitions and windows, of errors in computing heat loss by assuming maximum rates of heat flow due to maximum temperature differences as applying during the whole day, of changing temperature and mean temperature of the wall, and for the comparison of conductance values derived by computation with those found by actual measurements.

Strength of Interlocking-Rib Tile Walls, A. H. Stang, D. E. Parsons, and A. B. McDaniel (U. S. Department of Commerce, Bureau of Standards (Washington, D. C.) Technological Paper 366 (1928), pp. 389-408, figs. 10).—Tests of eight walls, 12 in. thick, 6 ft. long, and 9 ft. high, built of tile having interlocking ribs, are reported. Four walls were tested in compression, three under transverse loading, and one was subjected to a transverse load before being tested in compression. Lime, cement-lime, cement, and no mortars were used in the horizontal joints The wall with cement-lime mortar beds sustained a maximum transverse load about 2.5 times that taken by the wall with lime mortar beds and higher than any other tile wall so far tested at the bureau. Similarly, the compressive strength of the cement-lime mortar bedded wall was about 2.5 times that of the wall with lime mortar beds.

The conclusion was drawn that walls built of interlocking-rib tiles with staggered horizontal joints gave results in the transverse tests indicating that the resistance of the walls to side pressures was affected by the condition and nature of the cementing materials used in the walls. The compressive strength of these walls seemed to be directly dependent upon the workmanship and the mortar used in the horizontal joints. The results are taken to indicate that walls built of interlocking-rib hollow tile have considerably higher transverse strength and at least as high compressive strength as similar walls built of tile of the usual design.

An Observed Case of "Spontaneous" Ignition in Stable Manure, L. H. James, G. L. Birdell, and R. S. McKinney (Journal of Agricultural Research [U.S.] (Washington, D. C.) 36 (1928), No. 5, pp. 481-485, figs. 4).—In a contribution from the U. S. Department of Agriculture, it si reported that a pile of heating stable manure was observed to ignite spontaneously. When exposed to the air charred straw glowed to a firey red. Oxygen aeration of a small section of heating material produced a rapid increase in temperature of 26.5 deg. C. in 30 min.

Bond Between Concrete and Hollow Tile, J. C. Oleinik (Engineer and Contractor (Chicago, Ill.) 67 (1928), No. 1, pp. 19-21, figs. 5).—Studies, conducted by the Bureau of Standards, U. S. Department of Commerce, in cooperation with the Hollow Building Tile Association on the strength of the bond between hollow tiles and concrete in shear, are reported.

The results in general indicated that the strength in shear of the bond between hollow tiles and concrete was greatest when concrete containing the minimum amount of water necessary for its proper placement was used in combination with dry or dipped tiles of medium absorption. For dry cured specimens the bond strength in sheer increased with the strength of the concrete blocks between the tiles. For specimens made from dry tiles the bond strength in shear did not vary widely with tiles having absorptions between 5 and 20 per cent. Saturating the tiles reduced the bond strength in shear materially with tiles having absorptions between 5 and 20 per cent. Dipping the tiles did not reduce the bond strength appreciably. Damp curing increased the bond strength in shear of specimens made with dry tiles and concrete of wet consistency. With all other specimens damp storage seemed to decrease the strength of the bond. For specimens made from New Jersey fire clay tiles the ratio between the strengths of the concrete blocks and the cylinders increased as the water-cement ratio increased and as the amount of water in the batch decreased.

The Compression Refrigerating Machine, C. T. Voorhess (Chicago: Nickerson & Collins Co., 1927, pp. XVI + 607, pls. (69), figs. (166).—This book contains an analysis of many of the practical and theoretical features involved in the action of the compression refrigerating machine, including its thermodynamics and indicator diagram, and presents a study of ice making and its application. A large amount of graphic data on refrigeration is appended.

Dairy Stable Ventilation, F. L. Fairbanks (Journal of American Socelty of Heating and Ventilating Engineers (New York) 34 (1928), No. 2, pp. 125-136, figs. 9).—In a contribution from the New York Cornell Experiment Station the results of experiments in dairy stable ventilation and in measuring and indicating the movement of air in dairy stables are reported.

The results indicated that the essential factors in dairy stable ventilation are a heat reservoir maintained in the stable by means of floor outtakes the stimulation of convection currents, positive action of convection currents, the avoidance of drafts, complete mixing of fresh air and stable air, and a supply of from 50 to 60 cu. ft of air per min. per head ofstock.

Low-Cost Rural Construction, C. W. Kable (Electrical World (New York) 91 (1928), No. 20, pp. 1015-1017, figs. 5).—In a contribution from the Oregon Experiment Station data are presented on the utilization of lightweight X-frames for rural electric construction. Single-phase rural lines were constructed for $333 per mile.

Nebraska Tractor Tests, 1920-1927, Rules for Official Tractor Testing, and the Nebraska Tractor Law (Nebraska Station (Lincoln) Bulletin 224 (1928), pp. 39, figs. 6).—This bulletin summarizes all reports of Nebraska official tractor tests conducted since the work began in 1920 under the provisions of the Nebraska tractor law. During the 8 years of that period tests have been conducted on 147 different models and types of tractors. During the first 4 seasons of testing there were several tractors the claims for which had to be revised before they could complete the tests. During the last 4 years, however, every tractor tested has been able to go through the test and has met all original claims made for it. A summary of the data is presented in tabular form. A statement is given of recent changes in tractor design.

Present Tendencies in Motor-Fuel Quality, G. G. Brown (S.A.E. [Society of Automotive Engineers] Journal (New York) 22 (1928) No. 5, pp. 559-564).—In a contribution from the Universit of Michigan it is pointed out that the present tendency in fuel refinement is away from such misleading values as color and gravity. Ease of starting and good acceleration, particularly of a cold engine, demand high partial volatility even more than anti-knock value, while the development of maximum power and a high fuel efficiency in modern engines supplying a large amount of heat to the mixture demand a relatively high end point in the distillation tests.

It is shown that there is no economic advantages in buying anti-knock fuels at a 3-ct. premium, which now corresponds to about 15 or 16 per cent of the selling price, if an engine having a compression ratio of 5.5 to 1 can be operated satisfactorily on ordinary gasoline.

Wear Tests of Concrete, C. H. Scholer and H. Allen (Kansas Engineering Experiment Station (Manhattan) Bulletin 20 (1928), pp. figs. 19).—The first object of the test described in this bulletin was to develop a method of determining the resistance of concrete to wear which could be used in any laboratory having standard equipment. The second object was to study the effect of various factors on the resistance of concrete to wear.

It was found that the testing of three 9-in. spheres of 60-day concrete in standard paving brick rattler for 900 revolutions is a satisfactory and convenient method for testing the resistance to abrasion. The French coefficient of the coarse aggregate does not materially effect the resistance to wear or the strength of portland cement concrete of a 1: 2: 3.5 mix. This is taken to indicate that good results may be obtained by the use of any coarse aggregate which is structurally sound.

The use of a surface hardener increase the resistance of concrete to abrasion. The use of an excessive amount of mixing water was found to reduce the resistance to wear of concrete in about the same proportion as it reduced the strength. The replacement of 12.5 per cent or more of the volume of the portland cement with natural hydraulic cement in a 1: 2: 3.5 mix was found to reduce the strength of the concrets and the resistance to wear in proportion to the amount of portland cement replaced.

Lumnite cement concrete was found to have the same resistance to wear at 48 hr. as portland cement concrete of the same proportions at 60 days.

Shall I Buy a Combine? L. A. Reynoldson, J. H. Martin, and W. R. Humphries (U. S. Department of Agriculture (Washington, D. C.) Bulletin 1565 (1928), pp. 11 + 18, figs. 6).—Data obtained cooperatively by the Bureau of Agricultural Economics, Plant Industry, and Public Roads and the Kansas, Montana, Nebraska, Oklahoma, Texas, Illinois, Indiana, Pennsylvania, South Dakota, and Virginia Experiment Stations are briefly presented and discussed in their practical aspects.

It is pointed out that small grains, soybeans, clovers, grain sorghums, and other crops have been harvested and threshed successfully with combines. The advantages of the combine in comparison with other methods of harvesting and threshing are enumerated as the saving of labor, the elimination of transient labor, the early clearing of fields for tillage operations, the distribution of the straw on the land and the getting of the grain to the market earlier.

The disadvantages are the large investment required, the large amount of power consumed, the greater risk from grain, the greater risk to crops from storms and the difficulty of saving the straw for feed and bedding.

It is stated that a combine should not be purchased for harvesting less than from 100 to 150 acres annually, and that for smaller acreages other methods will usually be more economical.

AGRICULTURAL ENGINEERING

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A journal devoted to the advancement of the theory and practice of engineering as applied to agriculture and of the allied arts and sciences. Published monthly by the American Society of Agricultural Engineers, under the direction of the Publications Committee.

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

Original articles, papers, discussions, and reports may be reprinted from this publication, provided proper credit is given.

RAYMOND OLNEY, Editor

The "Combine" Up to Date

THE "combine" has been sweeping into America's wheat fields so fast the past few years that it has kept the engineers busy trying to keep pace with it. The development and adaptation of any machine to agricultural conditions and requirements calls for close attention of the engineers. Because the combine has come into use so rapidly, the situation has been particularly difficult from an engineering standpoint.

It is for the purpose of coordinating the efforts of agricultural engineers in the employ of the state agricultural colleges and federal department of agriculture and of the combine manufacturers—and bringing together the results of their studies and development work for their mutual benefit—that for the past three years the Power and Machinery Division of the American Society of Agricultural Engineers has, at its meeting in Chicago during the International Livestock Show in December, featured the combine and the closely related problem of grain drying. These meetings have been of value to the agricultural industry in pointing out the possibilities and limitations of the combine, to the combine manufacturers in indicating probable and desirable trends in development, and to the engineers in the exchange of ideas and experiences.

This issue of AGRICULTURAL ENGINEERING is practically entirely devoted to the proceedings of the combine and grain drying symposium held during the meeting of the Power and Machinery Division last December. These reports give an excellent cross section of the development and adaptation of the combine up to date, from the Atlantic seaboard to the Rocky Mountains and north to and including the prairie provinces of Canada. It is perhaps the most valuable, most complete, and most authoritative compilation of information on the combine that has ever been gotten together.

A Revolutionary Machine

IF THE introduction of the reaper at the close of the Civil War created a great furore because it released thousands of workers from agriculture, what about the combined harvester-thresher, or "combine" of today? Its potentialities for making possible increased grain production, for lowering costs and for releasing human labor are so vastly greater than those of the reaper or binder.

But there is no outcry against this machine because it displaces tens of thousands of workers. One reason is because hand labor is scarce at harvest time, and is becoming continually more so. Another reason is because we have learned some valuable lessons during the period of great industrial development in this country. Not the least important of these lessons is that, barring a general industrial depression, workers released from one industry by more efficient methods and improved machines are absorbed into other industries. In other words, mechanical power and modern machinery create more and better work for our people instead of less, even though it may leave some temporarily unemployed during the process of adjustment.

No machine has been introduced into agriculture, with the exception of the internal-combustion tractor, that has had such a profound effect on the industry as has the combine. The fact that it has made possible lowering the cost of producing wheat as much as twenty cents a bushel is a tremendously significant thing in itself. It has eliminated most of the drudgery of grain harvest for people on the farm. It has greatly simplified the operation of harvesting and threshing grain. At the same time it has created some perplexing problems, all of which, however, can be and are being solved.

The "combine" idea seems certain to exert a profound influence on the performing of other farming operations, and consequently on the development of other farm machines. A demand is being created to adapt the combine idea to harvesting corn, hay, potatoes, etc., and even to tillage operations.

The "combine" has already proven to be a most revolutionary machine, and when the history of the development of farm machinery during the next ten years is written, it will be seen to be a much more revolutionary machine than is apparent at this present time.

Professional Contacts

THE professional man who makes the greatest progress in his work, who is one of the outstanding successes in his field, is not the one who avoids contact with the fellow members of his profession, or who feels that such contact can not be particularly helpful to him.

No professional man has a monoply of ideas or knowledge concerning his field; he is never self-sufficient. All who are striving faithfully to accomplish a constructive work have something worthwhile to give out, and the greatest measure of success comes to him who gives as well as receives.

The fact that the meetings of the American Society of Agricultural Engineers are so well attended by members, many of whom travel long distances and at considerable personal sacrifice, indicates that agricultural engineers appreciate the value and need of frequent, closer association with others in their profession. Another fact is quite evident also in this connection, and that is that those who most consistently attend these meetings are, generally speaking, making the most progress and receiving the most recognition in their profession.

The meetings of the Society, including its annual meeting, the meetings of the professional divisions and of the geographical sections, offer the best opportunity for members to cultivate essential contacts. Attendance at these meetings should not be looked upon as an expense so much as an investment in professional advancement and well-being.

Who's Who in Agricultural Engineering

J. L. Strahan

I. D. Wood

E. E. Brackett

R. U. Blasingame

J. L. Strahan

James Louis Strahan (Mem. A.S.A.E.), acting chairman of the Structures Division, American Society of Agricultural Engineers, is chief agricultural engineer of the Louden Machinery Company. Educationally he is a product of Cornell University, having received his bachelor's degree in 1912 and his master's the following year. He remained at Cornell until 1919 as instructor and later as assistant professor of rural engineering, specializing in farm structures and drainage. During 1917 he also served as special investigator in dairy stable design, construction and improvement for the Vermont Department of Agriculture. The Massachusetts Agricultural College claimed him from the Empire State in 1919 and he stayed there until associating with the Louden Machinery Company in 1925, as ventilation engineer. Promotion to his present position came in 1927. Membership on various committees of the Society and of its Structures Division, holding the office of 2nd vice-president in 1926-27, and his long and varied experience in farm structures work, has prepared him amply for the chairmanship he now holds. His incidental accomplishments include the invention and patenting of an automatic device for controlling ventilating systems.

I. D. Wood

Ivan Daley Wood (Mem. A.S.A.E.), vice-chairman of the Land Reclamation Division, American Society of Agricultural Engineers, is state extension agent in agricultural engineering for the University of Nebraska. He studied agricultural engineering at the University of Nebraska from 1907 to 1912, when he was one of the first men in America to receive a bachelor's degree in agricultural engineering. He was awarded a scholarship and continued his studies at his alma mater in 1913, earning his master's degree. From 1909 to 1912 he was also student assistant in the civil engineering and agricultural engineering departments of the University and during the year 1912-13, instructor in rural architecture. For about a year in 1913-14 he was engineer in land reclamation for the John L. Roper Lumber Company of Norfolk, Va. From there he returned to Nebraska to take up his present work. The farm structures section of the Book of Rural Life, an encyclopedia of agriculture, was written by Mr. Wood. Throughout his membership in the Society he has been prominently identified with its structures, land reclamation and extension activities and in June will succeed to the chairmanship of the Land Reclamation Division.

E. E. Brackett

Elmer E. Brackett (Mem. A.S.A.E), vice-chairman of the Rural Electric Division, American Society of Agricultural Engineers, became acting head of the department of agricultural engineering of the University of Nebraska on February 1, when Prof. Sjogren, head of the department, started a year's leave of absence. Mr. Brackett grew up on a farm in southeast Nebraska and received his bachelor's degree in electrical engineering from the University of Nebraska in 1901. He was instructor in electrical engineering at the University of Pennsylvania for three and one-half years. In 1912 he returned to the University of Nebraska as a member of the staff of the agricultural engineering department. This connection has been continued since that time, with the exception of a year during the war when he was an engineer officer in the U. S. Air Service. As a member of the tractor testing board of the University of Nebraska he helped plan equipment and procedure for the tests, was engineer in charge of the tests for several years, and since then has again been a member of the board. He is also project leader of the Nebraska rural electric investigations, a position for which he is particularly well qualified by his farm background, electrical engineering training and agricultural engineering experience.

R. U. Blasingame

Ralph Upshaw Blasingame (Mem. A.S.A.E.), vice-chairman of the Power and Machinery Division of the American Society of Agricultural Engineers, is professor and head of the department of farm machinery at Pennsylvania State College. Born in Alabama, he attended Alabama Polytechnic Institute, where he received his bachelor's degree in civil engineering in 1908 and in agriculture in 1910. Since then he has been principal of the Cooper Academic and Industrial School of Cooper, Texas; held a fellowship at Iowa State College; received his bachelor's degree in agricultural engineering from Iowa State College (1913); spent two years at Pennsylvania State College as instructor in agronomy in charge of farm machinery work; was appointed head of the newly organized department of agricultural engineering, and agricultural engineering extension specialist, at Alabama Polytechnic Institute; returned to Pennsylvania State College in 1918 as associate professor, and later as professor of agronomy, in charge of farm machinery; helped organize and was made head of the department of farm machinery established at that institution in 1921. He will succeed to the chairmanship of the Power and Machinery Division at its annual meeting in June.

A. S. A. E. and Related Activities

Walker to World Engineering Congress

HARRY BRUCE WALKER, professor of agricultural engineering, and head of the department, at the University of California, has accepted the invitation extended by the Council of the American Society of Agricultural Engineers to act as the representative of the Society at the World Engineering Congress to be held at Tokio, Japan, in October of this year, and to present a paper on the subject, entitled "Engineering as Applied to Agriculture."

The purpose of the World Engineering Congress, the first of its kind ever held, is the advancement and diffusion of knowledge on scientific subjects relating to all branches of engineering. Leading engineers throughout the world will be present and take part in its deliberations. The American Committee of the Congress has general charge of the participation of the engineering organizations of this country who will participate in the Congress. The honorary chairman of the American Committee is Herbert Hoover. Elmer A. Sperry, president of the American Society of Mechanical Engineers, is chairman, and C. E. Grunsky, John W. Lieb, and C. F. Kettering are vice-chairmen.

In extending the invitation to the American Society of Agricultural Engineers to contribute to the program of the Congress, it was indicated that there was a strong demand for a paper featuring the application of engineering to the important industry of agriculture The Society is particularly fortunate in having secured Mr. Walker to represent it and to prepare the paper which will review the progress that has been made in this country in agricultural engineering. He is a past-president of the Society and has served in many important capacities in Society activities, including that of chairman of the College Division and representative of the Society on American Engineering Council.

Mr. Walker is a graduate in civil engineering from Iowa State College, and since graduation has served in various engineering capacities. During the World War he was a captain of engineers in the 78th Division of the U. S. Army and in the A.E.F. as assistant division engineer on engineering operations; he saw service in the St. Mihiel and Meuse-Argonne offensives.

Following graduation he was for several years drainage and irrigation engineer with the extension division of the Kansas State Agricultural College. He has also served as assistant state highway engineer, state irrigation engineer, associate professor of civil engineering, special consulting engineer of the U. S. Reclamation Service, engineer and later a member of the Kansas Water Commission, state supervisor of the Kansas Committee on the Relation of Electricity to Agriculture, and consulting engineer of the state game and forestry commission. Previous to his appointment last year to his present position, he served one year as director of the U.S.D.A. Survey of Research in Mechanical Farm Equipment.

In addition to being a member of the American Society of Agricultural Engineers, Mr. Walker also holds membership in the American Society of Civil Engineers, Kansas Engineering Society, and the Society for the Promotion of Engineering Education.

Iverson with Caterpillar

THE Caterpillar Tractor Company announces the appointment of Geo. W. Iverson as supervisor of agricultural sales, eastern division. Mr. Iverson assumed his new duties early this month and will have his headquarters at the eastern office of the company at Peoria, Illinois.

Mr. Iverson is a graduate in agricultural engineering of Iowa State College and received his professional degree from that institution in 1920. After seeing service both in this country and abroad during the World War, he became associated with the Advance-Rumely Company, first, as service engineer, then advertising manager, and for the past two years as divisional sales manager. During the entire period of his employment with this company he has had charge of the company's tractor schools which have been attended by approximately 75,000 students; this year the attendance will probably range between 40,000 and 50,000 students.

He joined the American Society of Agricultural Engineers in 1916, and has served with distinction on several committees. He was a member of the Council from 1922 to 1924, and chairman of the Power and Machinery Division 1926-27. He has also been active in the affairs of the National Association of Farm Equipment Manufacturers and was chairman of the sales and advertising managers department in 1927-28.

American Engineering Council Holds Ninth Annual Meeting

GROWTH in strength, prestige and activity of the American Engineering Council was revealed at its ninth annual meeting, January 14 and 15, in Washington, D. C.

The American Institute of Consulting Engineers has recently affiliated and the American Society of Civil Engineers has voted to affiliate with the Council. It is being looked to more and more by members of Congress and other public officials for reliable information on engineering questions of public interest. In addition to undertaking more special studies, its work of examining and reporting on proposed legislation is increasing and the number of national engineering problems that call for its study and recommendations are also on the increase.

L. W. Wallace, executive secretary of the council, outlined its organization and operation and the duties of the delegates. He also pointed to a few of the accomplishments of the past year, praised the Council's president, and called attention to the record of the organization in the past and to its hopes for the future.

Herbert Hoover, Mortimer E. Cooley, James Hartness, Dexter S. Kimball, and A. W. Berresford are the distinguished men who have served as president of the American Engineering Council. Mr. Berresford holds the office at present.

President Berresford, in addressing the assembly spoke of the impersonal nature of the Council and its work, and pointed to this as a reason for difficulty in explaining to many men the need of its work and their relation to it. He pointed to the importance of the Council as a source of technical information and unbiased opinion in engineering matters of public interest; to the value of the engineer to the country; and to great possibilities for engineering service through the American Engineering Council in the immediate future.

Special committees recently have completed reports on "Safety and Production," "Street Signs, Signals and Markings" and the Council's part of the study of "Recent Economic Changes in the United States."

In its business session the Council amended its constitution, elected one vice-president and reelected its

treasurer, announced committee appointments and heard a favorable report from the treasurer, through the chairman of its finance committee.

It also approved a recommendation of its administrative board that the Council endorse and promote the appointment of a larger engineering personnel to the Federal Radio Commission; heard and took action on the reports of the public affairs committee and patents committee; stated its opposition to the Cramton bill, Public Works bill, Prosperity Reserve bill and certain other proposed legislation; and voted to take appropriate measures to insure the inclusion in the Census of information on man-hour performance in industry. It further voted to authorize the appointment of a committee to study a proposed amendment to the federal constitution, relating to the control and administration of the nation's waters; and of a committee to study the activities and performance of the Army Engineer Corps.

Annual Meeting Dates Changed

JUNE 24, rather than June 17 as planned until recently, will mark the opening of the twenty-third annual meeting of the American Society of Agricultural Engineers at Dallas, Texas. The later date was recently decided upon by the Council of this Society.

Monday June 24 will be given over to a meeting of the College Division. Tuesday and Wednesday June 25 and 26, will be devoted to general sessions. The annual business meeting of the Society will be held on Tuesday evening and on Wednesday evening, the big annual banquet. On Thursday, June 27 one-half day, probably the morning, will be given to inspection trips and demonstrations. Simultaneous sessions of the technical divisions will occupy the remaining half of the day. Paper and addresses of outstanding interest to various agricultural engineers are being planned for the general session, including material from each technical division.

County Agents Report on Farm Machinery

AT A meeting of the Advisory Committee of the College Division of the American Society of Agricultural Engineers in Washington nearly a year ago, it was proposed that the county agricultural agents include in their reports a report on what had been accomplished in their respective counties along the lines of agricultural engineering, with particular reference to farm machinery. The proposal was approved by the Division of Agricultural Engineering of the U. S. Department of Agriculture, and Lewis A. Jones of that division was given the job of seeing to it that it was carried out.

While this may seem of minor importance, it is in effect a demand by the U. S. Department of Agriculture that the county agents show accomplishment along this line. It also puts farm machinery on an equal basis with other extension projects and, for the first time, gives the county agent credit for all the work he has done with farm machinery. It is one of the biggest steps ever taken in promoting farm machinery extension work, and, moreover, is an outstanding contribution to agricultural engineering development.

Rural Fire Departments

THE Agricultural Committee of the National Fire Waste Council, a voluntary federation of nineteen national organizations and four governmental bureaus interested in the reduction of fire waste and cooperating with the Chamber of Commerce of the United States in a nation-wide fire prevention campaign, has just issued an interesting bulletin, entitled "Rural Fire Departments." The bulletin was prepared by a subcommittee on rural fire departments, the chairman of which is William Draper Brinckloe, a member of the American Society of Agricultural Engineers, who has had considerable experience in the organization and operation of volunteer rural fire departments. Copies of this bulletin may be secured from the National Fire Waste Council, 1615 Eighth Street Northwest, Washington, D. C.

Necrology

W. K. Winterhalter

WILHELM K. WINTERHALTER, consulting agriculturist, of San Francisco, and an A.S.A.E. member since 1923, passed away at his home recently.

Mr. Winterhalter was born at Munich, Bavaria, February 12, 1868. After graduating in agriculture in his native country, he took post-graduate work in the agricultural college of the University of California. He was for a time secretary to Prof. E. W. Hilgard of the University of California, and later superintendent of the King City Ranch of the Spreckles Sugar Company, comprising 12,000 acres. Later he accepted a position as agriculturist with the American Beet Sugar Company, and rose to the position of consulting agriculturist, being sent to Europe by the company for the purpose of studying agricultural methods and improvements in beet culture and seed production. He was later placed in charge of the agricultural and farming operations of this company.

In 1911 he established his practice as a consulting agriculturist in San Francisco. He established several beet seed experiment stations in Germany, Canada, and United States.

Mr. Winterhalter was a member of the Academy of Sciences of San Francisco, of the Allgemeine Deutsche Landwirtschaft Gesellschaft of Berlin, and of the American Association of Sugar Beet Agriculturists.

He is survived by his widow and one daughter.

Personals of A.S.A.E. Members

F. D. Cornell, Jr., instructor in farm mechanics, West Virginia University, is author of Circular No. 53, entitled "Buildings and Equipment for the Livestock Farm," recently issued by West Virginia University, Morgantown.

A. W. Farrall recently became associated with the Douthhitt Engineering Co., 100 W. Monroe St., Chicago, Ill., where he will have charge of research and development work on dairy machinery. He was previously junior agricultural engineer in the agricultural engineering division of the University of California, where his work was principally devoted to the development of dairy equipment.

F. E. Fogle has resigned as assistant professor of agricultural engineering at Michigan State College to engage in farming operations near Okomos, Michigan.

W. M. Hurst, junior agricultural engineer, U. S. Department of Agriculture, is one of the authors of Farmers Bulletin No. 1557 of the U. S. Department of Agriculture, entitled "Harvesting Grain Sorghums." He is one of the authors of Circular No. 52 of the Texas Agricultural Experiment Station, entitled "Mechanical Harvesting of Cotton in Northwest Texas"; **Dan Scoates**, professor of agricultural engineering, A. & M. College of Texas, is another author of this circular. Mr. Hurst recently prepared a bulletin on the mechanical harvesting of cotton for the Pan-American Union.

C. H. Jefferson has been appointed instructor in farm building, in the department of agricultural engineering at Michigan State College, East Lansing, resigning his position with the Clay Equipment Corp., at Cedar Falls, Iowa.

G. C. Neff, vice-president Wisconsin Power and Light Company, is author of a treatise, entitled "Essentials for the Development of Rural Electric Service," which portrays in detail the organization, operation, etc., of the rural electric service department of his company This has been published as a serial report of the Rural Electric Service Committee of the National Electric Light Association.

H. B. Roe, agricultural engineer, Minnesota Agricultural Experiment Station, is author of a paper entitled "Productivity of Peat Soil as Influenced by Height of Ground Water Table," presented at the First International Congress of Soil Science in Washington, June, 1927. This paper has recently been issued in separate form.

New A.S.A.E. Members

Elmer J. Baker, Jr., secretary and associate editor, Farm Implement News Co., Chicago, Ill.

Raymond H. Bamer, superintendent of livestock, New York State College of Agriculture, Ithaca, N. Y.

Edward C. Bostock, general manager, Prairie Farm of Pitcairn Brothers, Inc., Philadelphia, Penna.

Arthur C. H. Cooke, rural service engineer, Central Power and Light Co., San Antonio, Tex.

John H. Fiessner, farm representative, Detroit Edison Company, Monroe, Mich.

Arthur E. Halterman, rural electric service manager, Suburban Electric Power Co., Waldorf, Md.

Theodore W. Johnson, agricultural draftsman and designer, John Deere Plow Works, Moline, Ill.

Edward A. Johnston, director of engineering, International Harvester Co., Chicago, Ill.

Stanley A. Knisely, director of research, Sheet Steel Trade Extension Committee, Cleveland, Ohio.

Wheeler McMillen, associate editor, "Farm & Fireside," Crowell Publishing Co., New York, N. Y.

Ralph W. Moltke, promotional engineer, Central Illinois Light Co., Peoria, Ill.

Russell S. Wolfe, blasting contractor, Orangeburg, S. C.

J. Frank S. Ziegler, farm manager, Prairie Farm, Alicia, Mich.

Transfer of Grade

Roy Bainer, assistant professor of agricultural engineering, Kansas State Agricultural College, Manhattan, Kan. (Junior to Associate Member.)

Cyrus A. Galley, experimental designer, John Deere Wagon Works, Moline, Ill. (Student to Junior Member.)

Paul R. Hoff, extension specialist, Ohio State University, Columbus, Ohio. (Student to Junior Member.)

W. Leland Zink, designer, General Implement Co., Racine, Wis. (Associate Member to Member.)

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the January issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Fred W. von Allmen, mechanical engineer, McDougal & Friedman, Consulting Engineers, Montreal, Canada.

Albert R. Alton, chief draftsman, Minneapolis Steel & Machinery Co., Minneapolis, Minn.

Harold S. Fielder, chief sales engineer, Cherry Burrell Corp., Berwyn, Ill.

Charles E. Fleming, architect, Louden Machinery Co., Fairfield, Ia.

Roy E. Hayman, in charge of rural electrification, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

Howard H. Weber, assistant engineer, Rome Wire Co., Rome, N. Y.

Marlin S. Kelly, secretary-treasurer, Allen Tractor & Implement Co., Liberal, Kans.

H. F. Kirkpatrick, rural service department, Idaho Power Co., Blackfoot, Idaho.

William T. McCaskey, director, rural service department, Middle West Utilities Co., Chicago, Ill.

Martel P. McNeely, advertising agent and farmer, Educational Advertising Agency, Joliet, Ill., and Sproule & McNeely Farms, Manhattan, Ill.

Geo. H. Nystrom, division sales manager, John Deere Plow Co., Kansas City, Mo.

Orville J. Parks, implement engineer, Minneapolis Steel & Machinery Co., Minneapolis, Minn.

Byron J. Showers, agriculturist, Romola, Inc., Phoenix, Ariz.

N. P. Sokoloff, director, North Caucasian Regional Agricultural Experiment Station, U.S.S.R.

David C. Sprague, instructor in dairy manufacturing, Iowa State College, Ames, Ia.

E. G. Stahl, agricultural engineer, San Joaquin Light & Power Corp., Fresno, Calif.

Carl G. Strandlund, implement designer, John Deere Plow Works, Moline, Ill.

James R. Tavernetti, field agricultural engineer, University of California, Davis, Calif.

Clare M. White, instructor in agricultural engineering, Michigan State College, East Lansing, Mich.

Charles D. Wiman, president, Deere & Company, Moline, Ill.

Transfer of Grade

Robert M. Merrill, agricultural engineer, U. S. Department of Agriculture, Bureau of Public Roads, Toledo, Ohio. (Associate Member to Member.)

E. R. Raney, agricultural engineer, J. C. Penney-Gwinn Corp., Green Cove Springs, Fla. (Associate Member to Member.)

Employment Bulletin

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

AGRICULTURAL MACHINE DESIGNER, age 38, seeks larger opportunity. A graduate in mechanical engineering, with five years of machine shop practice and mechanical drafting, and ten years in experimental department of a large agricultural implement organization manufacturing a full line of tillage and harvesting tools. Experience at bench, floor, field work drafting specification lists, instruction book, repair lists and photographing. Capable of handling men. MA-155

AGRICULTURAL ENGINEER desires position as manager or assistant of an agricultural enterprise where ability will be recognized. Have had experience in managing sugar estate in West Indies and have successfully handled labor. Agricultural college graduate, 37 years old and married, will go anywhere. MA-158

AGRICULTURAL ENGINEER, graduate from the Kansas Sate Agricultural College, desires connection in residential college work, teaching or research. Have had practical farm experience and have been an extension specialist since graduation. MA-159.

Positions Open

AGRICULTURAL ENGINEER who has had experience with cultivating and planting machinery wanted by an organization of consulting engineers. Location Middle West. PO-151

ENGINEER WANTED to fill opening in growing organization. A young man with training in drafting, with creative ability in designing and with experience with tractors, threshers and combines preferred. PO-152.